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Tucson Electric Power

88 E Broadway Blvd | Post Office Box 711 | HQE 910 | Tucson, AZ 85701

December 27, 2019

Docket Control
Arizona Corporation Commission
1200 West Washington Street
Phoenix, AZ 85007

Re: Comprehensive Transportation Electrification Plan for Arizona
Docket No. RU-00000A-18-0284

To Whom It May Concern:

Pursuant to Decision No. 77289 (July 19, 2019) ("Decision") Public Service Corporations ("PSCs") were directed as follows:

> *PSCs shall coordinate and jointly develop, with stakeholder input, a joint, long-term, comprehensive transportation electrification plan for Arizona, to be filed by December 31, 2019, for Commission review and approval. This plan should include all pilot program activities and lessons learned from 2019. The comprehensive plan shall incorporate goals and metrics for evaluating success, and the PSCs shall report publicly on a semi-annual and annual basis on their progress, achievements, budget, and expenditures.*

In accordance with the Decision, the Tucson Electric Power Company hereby submits a joint statewide transportation electrification plan on behalf of itself, Arizona Public Service Company and UNS Electric, Inc.

Sincerely,

Dallas J. Dukes
VP, Energy Programs and Pricing
Tucson Electric Power Company
UNS Electric, Inc.

Barbara Lockwood
VP, Regulation
Arizona Public Service Company

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Arizona Statewide Transportation Electrification Plan

December 2019

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Executive Summary

Electric vehicle (EV) technology has progressed dramatically in recent years and is beginning to create changes to our conventional transportation system. Transportation electrification (TE) can provide significant benefits to EV purchasers and utility customers generally, improves air quality, and aids in the growth of the Arizona economy. To unlock this value, Arizona's electric utilities, regulatory agencies, policymakers, automakers, third-party charging service providers, and other stakeholders must work together to support EV adoption while also integrating this new load into the existing electricity system. As such in Decision No. 77289, the Arizona Corporation Commission ordered the state's Public Service Corporations (PSCs) to develop a long-term, comprehensive Statewide Transportation Electrification Plan (TE Plan) for Arizona. This strategic plan will provide a roadmap for TE in Arizona, focused on realizing the associated benefits for all residents in the state.

This report constitutes Phase One of a two-part process. Phase One provides a conceptual framework for the Statewide Transportation Electrification Plan for Arizona, including planned or proposed near-term utility actions to support the growth of EVs in the state. Phase Two will build upon this initial roadmap, with input from key stakeholders including non-governmental organizations (NGOs), government agencies and utilities. Phase Two will incorporate in-depth analyses of potential TE opportunities including air quality and economic development opportunities and will develop detailed implementation strategies for utilities and other stakeholders.

This Phase One report:

- Documents the current state of TE technologies and their level of adoption;
- Describes existing policies, programs and initiatives focused on TE;
- Summarizes the perspectives of Arizona stakeholders on TE and the role of electric utilities;
- Discusses the air quality benefits afforded by TE;
- Identifies key barriers and opportunities for developing the TE market in Arizona;
- Proposes near-term actions and initiatives the utilities will take to address barriers to TE development; and
- Outlines the topics of further and stakeholder collaboration to be addressed in Phase Two.

While TE technology has been developing across different segments of the transportation sector, certain transportation modes offer more promising near-term opportunities given their level of technical maturity. Near-term opportunities include electrification of **light-duty vehicles**, **medium-duty parcel vans**, **truck stops**, **transport refrigeration units**, and **nonroad vehicles or equipment**.

In Phase One, a "gaps analysis" of light-duty vehicles was performed to assess near-term opportunities for the electric utilities and other stakeholders to take action in order to realize the benefits of TE. The following table summarizes this analysis, providing select examples of current Arizona Public Service (APS), Tucson Electric Power (TEP) and UNS Electric, Inc. ("UNS Electric") – collectively, the "utilities" – initiatives aimed at overcoming TE barriers to light-duty EVs. The "Addressable Gap" describes how the barrier

persists beyond current utility initiatives and can help to inform the utilities' actions as they further develop their TE programs.

Barriers are discussed in further detail in Chapter 2, while detailed descriptions of the full complement of current utility TE initiatives are included in Chapter 5. Chapter 7 provides the full gaps analysis and descriptions of near-term utility actions that will help to address remaining barriers.

Not all of the gaps can be closed – in full or in part – by the utilities alone. Through more intensive engagement with state and local governments and stakeholders in Phase Two, utilities and other participants will identify the need for, and seek the support of, these important partners.

Table 1: Transportation Electrification Gaps Analysis (light-duty vehicles)

Market Barrier	Potential Utility Actions	Current Utility Initiatives (Select Examples)	Addressable Gap
Limited Awareness of EVs	Education & Marketing Electrify utility vehicles	APS participation in EV events TEP Residential EV Calculator	EVs remain outside of most consumers' consideration when purchasing a vehicle
EV Model Availability	None	None	EV models remain largely smaller and/or luxury vehicles (this gap is not directly addressable by utilities)
Upfront Cost Premium	Employee discount programs Engage automakers	TEP planned *Walk the Talk* employee program Nissan LEAF Discount	Upfront cost of EVs deters customers, even when total cost of ownership (TCO) is lower
Lack of Charging Infrastructure & Related Range Anxiety	Deploy additional EV supply equipment (EVSE) (public, workplace, multi-family) Advocate for EV-readiness in building codes	APS *Take Charge AZ* program APS *Charging Siting* analysis TEP *Smart Homes EV* and *Smart Cities EV* programs Maricopa Association of Governments (MAG) EV pre-wiring guidance (from SRP)	Charging infrastructure to address range anxiety and spur EV adoption lags current installations
Rate Design	Design alternate tariffs for EV service providers	APS and TEP plans to introduce DC Fast Charging (DCFC) rates	Demand charges present a challenge for EV service providers at current low utilization rates
Lack of Dealership Incentives	Engage automakers	Nissan LEAF Discount	Conventional light-duty vehicles will remain default choice without additional dealer incentive to sell EVs

Grid Integration Challenge	Potential Utility Actions	Current Utility Initiatives (Select Examples)	Addressable Gap
Distribution Impacts and Upgrade Costs	Expand EV TOU rate options EV service provider infrastructure buildout in low-cost locations Pilot programs to understand grid impacts	TEP EV TOU discount and planned EV-specific TOU rates APS TOU rates APS proposed *Demand Management for EV Charging* pilot program	The need to manage charging will become more acute as EV loads grow; without active planning upgrade costs will be high
Integration of Renewables	Support and enable expanded workplace charging	APS *Take Charge AZ* program TEP *Smart Cities EV* program	Most EV charging currently takes place at home and is poorly aligned with the timing of renewable generation

As demonstrated by the select example initiatives in Table 1, the utilities are already running programs that are aimed at addressing many of these barriers. In Phase Two the utilities will focus their efforts on expanding the programs that are most effectively addressing these key barriers, including conducting cost-benefit analyses and other research initiatives, establishing goals and metrics for evaluating success, engaging stakeholders to ensure that their initiatives are helping to develop TE in Arizona in a way that meets the needs of a broad and representative range of residents, and collaborating with state and local agencies to maximize programmatic impacts. Figure 1 provides an overview of the two project phases.

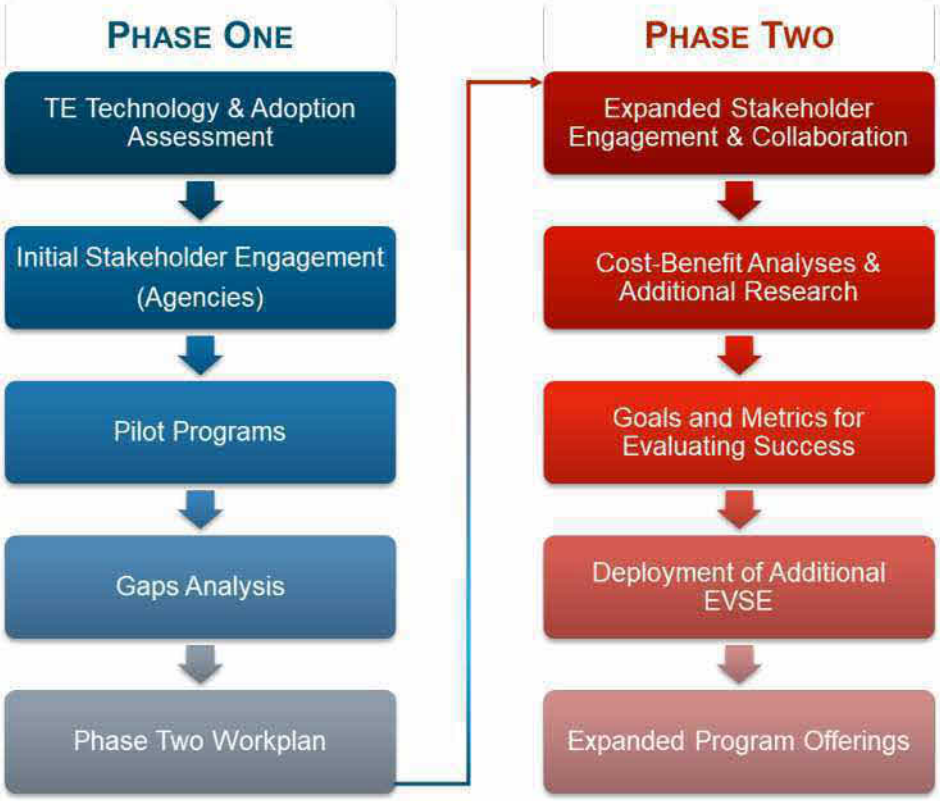

Figure 1: Phases One and Two of the Strategic Transportation Electrification Plan

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1) Introduction

Long perceived as a technology of the future, electric vehicles (EVs) have entered the mainstream and are rapidly becoming an important component of the modern transportation system. Automakers offer dozens of models today and will release an increasing variety of options over the next several years, as detailed in Figure 2 below.

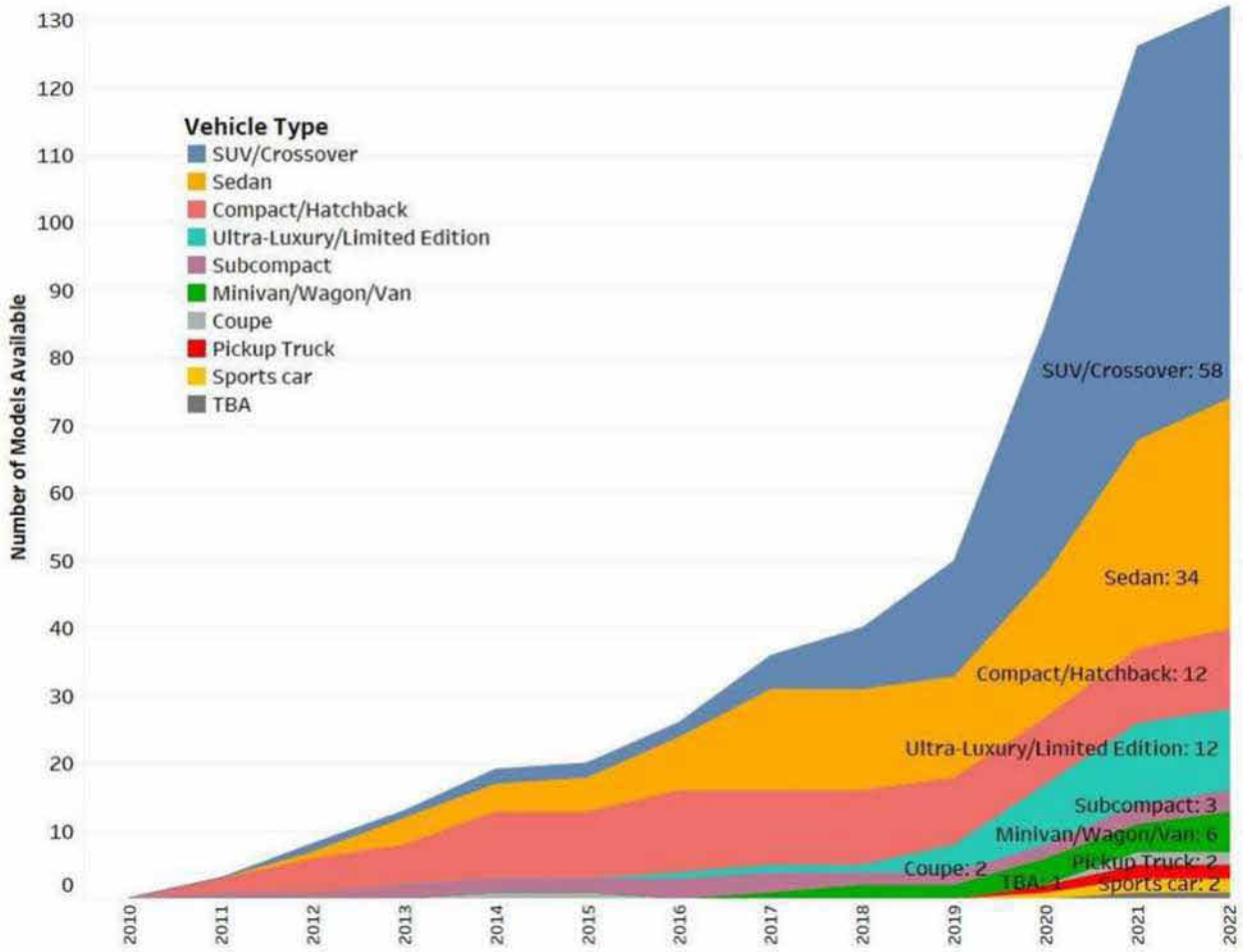

Figure 2: Count of EV models available or announced, 2010 – 2022[1]

With proper planning and integration, transportation electrification (TE) offers widespread opportunities for EV driver and utility customer savings, air quality improvements, increased mobility choices and economic development. Given the scale of this potential shift in the transportation sector, however, achieving these benefits requires coordinated action between numerous players including electric utilities, regulatory agencies, policymakers, automakers and third-party charging service providers, among others. This report – Phase One of a two-part process – aims to provide an important starting point for

[1] Electric Power Research Institute, "Overview of EV Market and PHEV Technology," July 8, 2019.

this coordination effort by outlining key areas of opportunity in Arizona as well as barriers to achieving them, and by describing the initial actions Arizona Public Service (APS) and Tucson Electric Power (TEP and UNS Electric, Inc. ("UNS Electric") are taking to realize the benefits of TE. Phase Two will build upon this initial roadmap, incorporating in-depth analyses of potential TE opportunities and developing detailed implementation strategies for utility initiatives. Phase Two is discussed in further detail in Chapter 8.

The Opportunity

Transportation electrification can provide numerous benefits to EV drivers, utility customers, and the Arizona economy overall. Residents adopting an EV can save on fuel and maintenance costs, utility customers can benefit from increased utilization of utility assets. EVs would replace internal combustion engines (ICE), thereby reducing emissions of harmful air pollution, directly benefiting the health of all Arizonans. Additionally, the emergent TE industry, which is already bringing investment and new jobs to the state, would help to grow Arizona's economy. For example, automaker Lucid Motors recently broke ground on its EV manufacturing facility in Casa Grande, which is projected to provide 4,800 direct and indirect jobs in the next decade and $32 billion in local revenue impacts over the next 20 years.[2]

Arizona Corporation Commission TE Policy and Directive

Over the past two years the Arizona Corporation Commission (ACC or Commission) has been considering TE and the role of the electric utilities in this area. In November 2018 the Commission Utilities Division Staff (Staff) was directed to develop a *Policy Statement on Electric Vehicles, EV Infrastructure, and the Electrification of the Transportation Sector in Arizona* (EV Policy). Staff developed the requested policy statement, informed in part through discussions with stakeholders at two meetings held in late 2018; the policy was formally adopted by the Commission in January 2019.[3] The EV Policy addressed key TE-related topics and questions, encouraged the utilities to invest in infrastructure and programs to support EV charging and encourage widespread adoption of TE, and directed Commission Staff to develop an implementation plan for the policy statement.

Through continued discussions with stakeholders at two additional workshops (held in March 2019) and in written comments filed in the docket,[4] the *ACC Staff Implementation Plan for the Electric Vehicles, Electric Vehicle Infrastructure, and the Electrification of the Transportation Sector in Arizona Policy Statement* (Plan or Commission Plan) was adopted by the ACC in July 2019.[5] This Plan provides guidelines to the utilities as to how best to implement the Commission's EV Policy, including direction on development of pilot programs, EV rate design, cost recovery of TE investments, education and outreach activities, charging station siting and infrastructure development, and periodic reporting on TE activities. This plan also directs the utilities to develop a "joint, long-term, comprehensive transportation electrification plan for Arizona" by December 31, 2019. This Phase One report constitutes the utilities'

[2] TechCrunch, "Lucid Motors breaks ground on its $700 million Arizona factory," December 2, 2019. Available at: https://techcrunch.com/2019/12/02/lucid-motors-breaks-ground-on-its-700-million-arizona-factory/.
[3] Arizona Corporation Commission, "Decision No.77044," January 16, 2019.
[4] RU-0000A-18-0284.
[5] Arizona Corporation Commission, "Decision No. 77289," July 19, 2019.

plan, which will be further developed with additional detail and supporting analysis in Phase Two beginning in early 2020.

Approaches to Developing TE Strategic Plans

A TE strategic plan will provide the roadmap to cost-effective, beneficial electrification of transportation in Arizona. Several states have started down this road and have taken different approaches to planning for TE. Energy regulators in some states have directed utilities to develop comprehensive plans or portfolios of pilot programs. Some state governments have also, or instead, developed strategic plans that focus on how state agencies should work together and with utilities and other stakeholders to promote TE. In blazing its own trail Arizona can draw upon the paths other states have followed.

The scope of Commission driven plans and the extent of regulators' involvement in their development has varied, as illustrated by the following examples:

- The Hawaiian Electric Company (HECO), at the direction of the Hawai'i Public Utilities Commission (HPUC), developed a comprehensive, long term strategic roadmap. The roadmap lays out HECO's planned TE initiatives over the next decade for light, medium and heavy-duty vehicles, and equipment at airports, seaports and military bases. Since HECO serves all of Hawaii's main populated islands except Kauai, it is practically a statewide plan. It focuses on HECO's plans, but also identifies complementary roles and actions for government and other stakeholders. In developing the roadmap HECO engaged a wide range of stakeholders including state and local governments, automakers, auto dealerships, electric vehicle service providers (EVSPs), transportation network companies (TNCs), environmental groups, consumer advocates, the military and the University of Hawai'i. HECO submitted its Electrification of Transportation Strategic Roadmap to the Commission in March 2018.[6] The HPUC took public comment on the plan and has since provided direction to HPUC on its priorities for implementation.[7]
- The Maryland Public Service Commission charged a stakeholder group, the EV Work Group, with developing a coordinated statewide approach to EV rates, deploying electric vehicle supply equipment (EVSE), managing grid impacts, and electrifying fleets. The process culminated in a filing by Maryland's four investor owned utilities (IOUs) and numerous stakeholders requesting Commission approval of a proposed EV Portfolio, which focused mainly on rate design and utility investments in EV charging infrastructure for light-duty vehicles (LDVs). In 2019 the Maryland Public Service Commission eventually approved scaled down versions of each utility's proposed EV Portfolio, and the utilities are now implementing the authorized programs.[8] More recently Governor Hogan enlisted the National Governors Association (which he chairs) to convene state agencies, utilities and key stakeholders to examine the full spectrum of TE opportunities in Maryland.

[6] Hawaiian Electric Companies, "Electrification of Transportation Strategic Roadmap," March 2018. Available at: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/electrification_of_transportation/201803_eot_roadmap.pdf.
[7] Hawaii Public Utilities Commission, "Order No. 36448," July 31, 2019. Available at: https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A19H01B00118I00099.
[8] Maryland Public Service Commission, "Order No. 88997," January 14, 2019. Available at: https://www.psc.state.md.us/wp-content/uploads/Order-No.-88997-Case-No.-9478-EV-Portfolio-Order.pdf.

- The Michigan Public Service Commission oversaw a stakeholder process that resulted in proposals for utility pilots that DTE and Consumers Energy then rolled into rate cases. In a pair of technical workshops, the Michigan Public Service Commission sought input from stakeholders on priorities for utility programs and then provided guidance to the utilities.[9,10] As in Maryland, the emphasis was on rates and charging infrastructure for light duty vehicles.
- Although California leads the nation in TE the California Public Utility Commission (CPUC) has yet to provide detailed direction to its jurisdictional utilities: it has authorized over a billion dollars in ratepayer funding for utility TE initiatives on a case-by-case basis. Change is afoot, however. In late 2018 the CPUC opened a new rulemaking to examined lessons learned from the initial rounds of utility programs and to consider requiring the utilities to develop strategic plans.[11] The CPUC plans to release a draft *Transportation Electrification Framework* for stakeholder comment before the end of 2019. The framework is intended "to establish a common and comprehensive framework for IOU investments in TE in California, aligned with" legislative direction and "will help guide the next chapter of policies and programs supporting California's [Zero Emission Vehicle (ZEV)] infrastructure."[12]

California and Colorado provide examples of states that have developed strategic plans that focus on how state agencies should work together to promote TE. The 2018 Colorado Electric Vehicle Plan focuses on the state's efforts to deploy public charging infrastructure, especially along major corridors.[13] Starting in 2013, the California Governor's Office of Business Development has facilitated collaborative interagency efforts to develop and update and expansive statewide ZEV Acton Plan that describes the role of leading and supporting state agencies in implementing the state's TE initiatives across all sectors of goods and people movement.[14]

These examples of different approaches to strategic TE planning can help to guide Arizona as it expands its own efforts in this area.

Report Overview

This Phase One report outlines the current state of TE technology, discusses the key barriers to adoption, provides an overview of Arizona-specific context including key policies and stakeholder perspectives, and describes the remaining gaps to be addressed in order to unlock the benefits of TE in the state. Phase Two

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[9] Michigan Public Service Commission, "Order Adopting Guiding Principles and Commencing a Second Collaborative Technical Conference," December 20, 2017. Available at: https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t0000001X2MFAA0.

[10] Michigan Public Service Commission, "Order Following the Second Collaborative Technical Conference," March 29, 2018. Available at: https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t0000002286rAAA

[11] California Public Utilities Commission, "Order Instituting Rulemaking to Continue the Development of Rates and Infrastructure for Vehicle Electrification and Closing Rulemaking 13-11-007," December 19, 2018. Available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M252/K025/252025566.PDF.

[12] Ibid.

[13] Colorado Energy Office, "Colorado Electric Vehicle Plan," January 2018. Available at: https://www.colorado.gov/pacific/energyoffice/atom/162026.

[14] See: http://www.business.ca.gov/ZEV-Action-Plan for history of the planning process and links to the 2016 Plan and 2018 Update.

will be to further develop the strategic Statewide Transportation Electrification Plan, focusing on the areas of near-term opportunity discussed in this report.

The report is structured as follows:

- Chapter 2 provides an overview of the status of transportation electrification technologies and the primary barriers to adoption, highlighting near-term opportunities.
- Chapter 3 describes the federal, state and local TE policies and initiatives that shape the legal and regulatory landscape for EVs.
- Chapter 4 summarizes the primary issues of interest to different TE stakeholders in Arizona, describing areas of agreement as well as ongoing challenges.
- Chapter 5 details the various programs and initiatives that APS and TEP currently offering or developing in support of TE.
- Chapter 6 briefly describes the scale of TE opportunities in Arizona.
- Chapter 7 provides an assessment of how well the current utility initiatives are addressing the primary barriers to TE, highlighting gaps that if unaddressed will limit uptake of these technologies.
- Chapter 8 outlines the primary actions that the utilities will undertake in Phase Two in order to further develop the strategic Statewide Transportation Electrification Plan.

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This report has been developed in collaboration with *Energy and Environmental Economics, Inc.* (E3), an energy consulting firm with expertise in the economics and public policy of TE and extensive experience supporting utility strategic planning for TE.

2) Transportation Electrification Technology and Adoption Assessment

The first step in determining how to best support transportation electrification and deliver its benefits is to assess the state of TE technologies and their market potential in Arizona, and to determine the barriers to adoption and grid integration that these vehicles face. As described in this chapter, this TE assessment demonstrates that the more mature electrified technologies with significant near-term market potential in Arizona are light-duty personal vehicles, TNC fleets, medium-duty parcel vans, truck stop electrification, transport refrigeration units and several types of nonroad vehicles or equipment. Accordingly, the utilities propose to focus on these opportunities in the near term, while continuing to assess the potential of other electrified technologies for additional focus in the medium and longer term, including through opportunities to collaborate with other stakeholders working to expand TE in Arizona.

Assessment Approach

Our assessment of the maturity of electrified technologies relies primarily on analysis prepared by the California Air Resource Board (CARB), whose transportation experts regularly review progress toward commercialization of low- and zero-emission vehicle technologies. They assign a Technology Readiness Level (TRL) using a methodology originally developed by NASA.[15]

Figure 3: CARB Commercialization Pathways and Technology Readiness Levels

The utilities will be most effective at supporting TE technologies in the early market entry phase (TRL 9), when customers begin deploying new technologies. There is also opportunity to provide technical support to commercial and industrial customers interested in demonstrating or piloting medium-duty (MD) and heavy-duty vehicle (HD) technologies or smart charging technologies at earlier levels of development (TRL 6-8). These demonstration projects will help to identify potential grid impacts of MD and HD technologies

[15] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives," September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.

and allow for investigation of potential solutions to manage and/or mitigate these impacts. Demonstration projects of this kind will be further explored in Phase Two.

Electric cars are clearly in the early commercial phase and some progress is evident for light-duty trucks.[16] As shown in Figure 4 below, many MD and HD battery electric vehicles (BEVs) are not as far along in their commercialization. However, several of these vehicle technologies are mature and have significant potential market penetration in Arizona including airport ground support equipment (GSE) and last-mile MD delivery trucks and vans. Electrified transport refrigeration units (TRUs or eTRUs) also have potential applications transporting produce and other perishables. Electrified MD delivery trucks, potentially a significant market in the Phoenix area, have recently transitioned from pilots to early market entry, while HD delivery trucks are still being demonstrated.

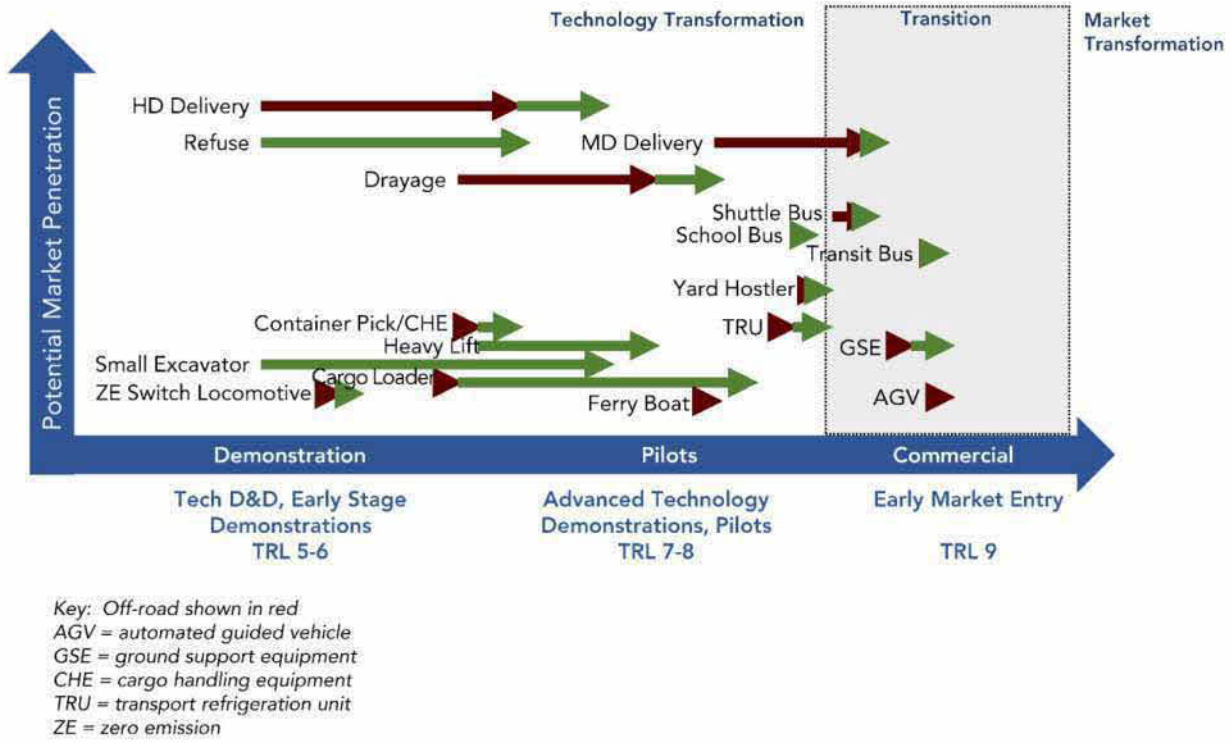

Figure 4: CARB assessment of technology status for MD and HD battery-electric vehicle technologies[17] (brown and green arrows depict 2018 and 2019 progress, respectively)

Key Barriers

The barriers facing EVs across the spectrum of vehicle types fall into the nine major categories outlined below in Table 2, which represent a synthesis of stakeholder interviews, comments submitted to the ACC,

[16] Light-duty trucks encompass Classes 1-3, weighing up to 14,000 lbs., including pickup trucks and large SUVs.
[17] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives," September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.

and literature reviews. The following sections discuss each vehicle segment in further detail, laying out the current state of each technology and the specific barriers and challenges each face.

Table 2. Barriers and challenges facing TE adoption and grid integration

Barriers to Adoption	
Limited awareness, understanding and enthusiasm for EVs	Awareness of and enthusiasm for electric vehicles remains very low outside of environmentally motivated early adopters.
EV model availability	Though increasing, the number and types of EV models have historically been relatively small. SUV and light-duty truck models remain limited, as do medium-duty and heavy-duty technologies.
Upfront cost premium of EVs over comparable conventional vehicles	Total cost of ownership can be lower for EVs relative to their internal-combustion engine counterparts, but higher upfront costs, even with available incentives, remain a barrier.
Lack of charging infrastructure and associated range anxiety	Despite numerous studies showing that 80% or more of regular trips can be accomplished with an EV, consumers remain anxious about the ability to take long trips and recharge if their battery is unexpectedly low. Fleet operators often require that every vehicle they own is capable of completing any route, which can limit use of EVs.
Demand charge costs for bus operators and commercial and industrial customers	Demand charges could create challenges during initial periods of lower utilization.
Lack of dealership incentive to sell EVs	Mainly an issue for the personal vehicle market. Buyers report having to educate car salespeople on EVs. Dealers are also disincentivized to forego the higher revenue from ongoing maintenance of ICE vehicles.
Limited availability of trained vehicle service technicians	Mainly an issue for the MDV and HDV segments. EVs remain a very low percentage of the overall market, with lower ongoing maintenance costs, limiting incentives to train and hire service technicians.
Grid Integration Challenges	
Need to proactively plan and incentivize customers to reduce impacts on distribution grid and associated upgrade costs	Charging loads for EVs are fundamentally different than other end-use load types for which the distribution system has been designed and built. Left unmanaged, these loads are likely to have high peak load coincidence factors.[18]
Need to incentivize charging that supports renewable integration	Default charging behavior for residential customers tends to be at home during the evening or overnight. Incentives and workplace charging infrastructure can encourage daytime charging during periods of low-cost solar generation.

[18] Utility Dive, Walton, R., "Uncoordinated trouble? Electric vehicles can be a grid asset, but only with planning and investments," January 31, 2018. Available at: https://www.utilitydive.com/news/uncoordinated-trouble-electric-vehicles-can-be-a-grid-asset-but-only-with/515787/.

Light-Duty Vehicles

MATURITY, ADOPTION AND MARKET SIZE

Electrification of LDVs is by far the largest opportunity for TE in Arizona. In the first half of 2019, BEVs and plug-in hybrid electric vehicles (PHEVs) collectively represented only 2.4% of new LDV registrations in the state.[19] However, EV sales grew every year from 2011 through 2018, as shown in Figure 5 below. The EV adoption forecast APS and Navigant Consulting have recently completed anticipates a statewide EV population of nearly 600,000 by 2038 in the base business-as-usual case.[20] Under strong market transformation policies this population could reach 1.5 million by 2038.

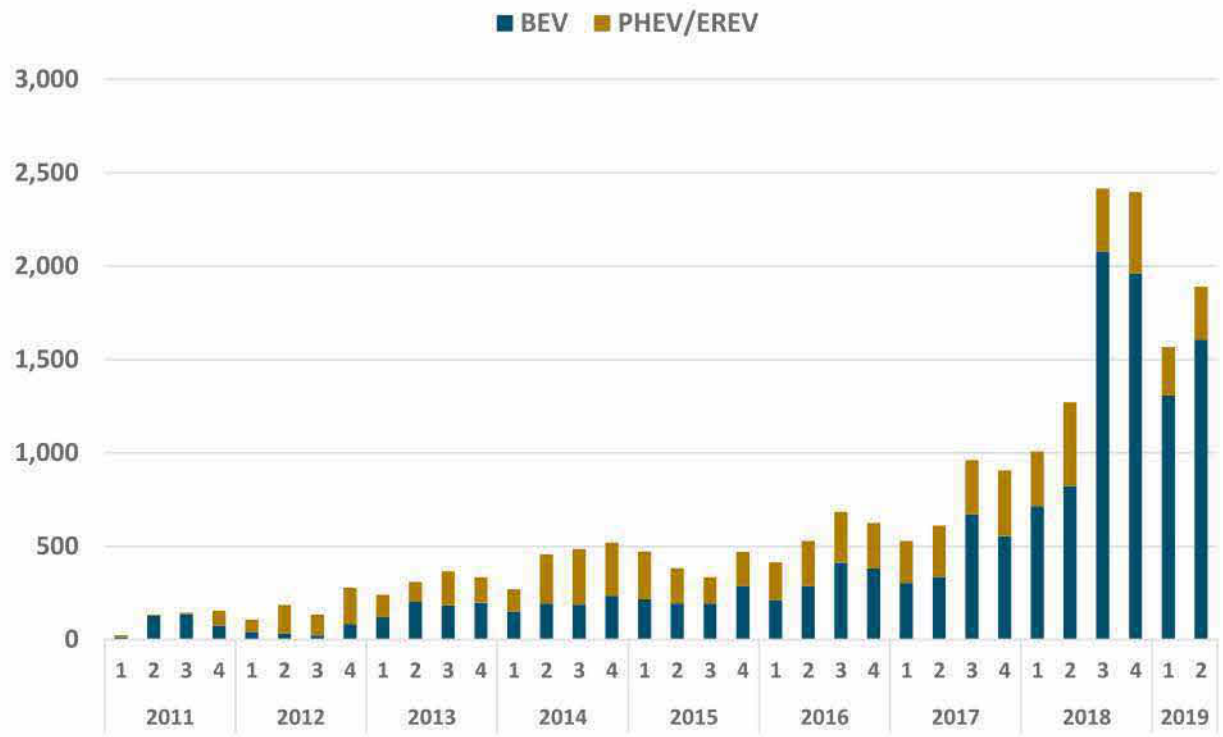

Figure 5: Quarterly EV Sales in Arizona[21]

Light-duty EV technology is already in the early commercial stage and is maturing steadily. The market for EVs remains largely policy-driven, so small manufacturing volumes and ongoing technology development translate into higher costs relative to conventional vehicles. Aggressive public policies in China, Europe,

[19] Alliance of Automobile Manufacturers, "Advanced Technology Vehicle Sales Dashboard," 2019. Available at: https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/.
[20] Navigant Consulting, "Electric Vehicle Adoption Forecast and Charging Station Siting Analysis: Arizona Public Service," October 2, 2019.
[21] Adapted from Atlas Public Policy, "State EV Sales." Updated November 2019.

and the zero emission vehicle (ZEV) states[22] are delivering the expected market transformation. The value proposition of EVs is improving as rapidly declining battery prices reduce component costs and the increasing energy density of battery packs extends driving range. EV adoption forecasts continue to be revised upward:[23] both Bloomberg New Energy Finance and McKinsey project that light-duty EVs will reach price parity with internal combustion engine vehicles by the mid-2020s (see Figure 6 below).[24,25] Bloomberg has recently reported that certain EV models will be competitive on an upfront price basis as soon as 2022.[26] Less optimistic forecasts estimate price parity will be reached around 2030.

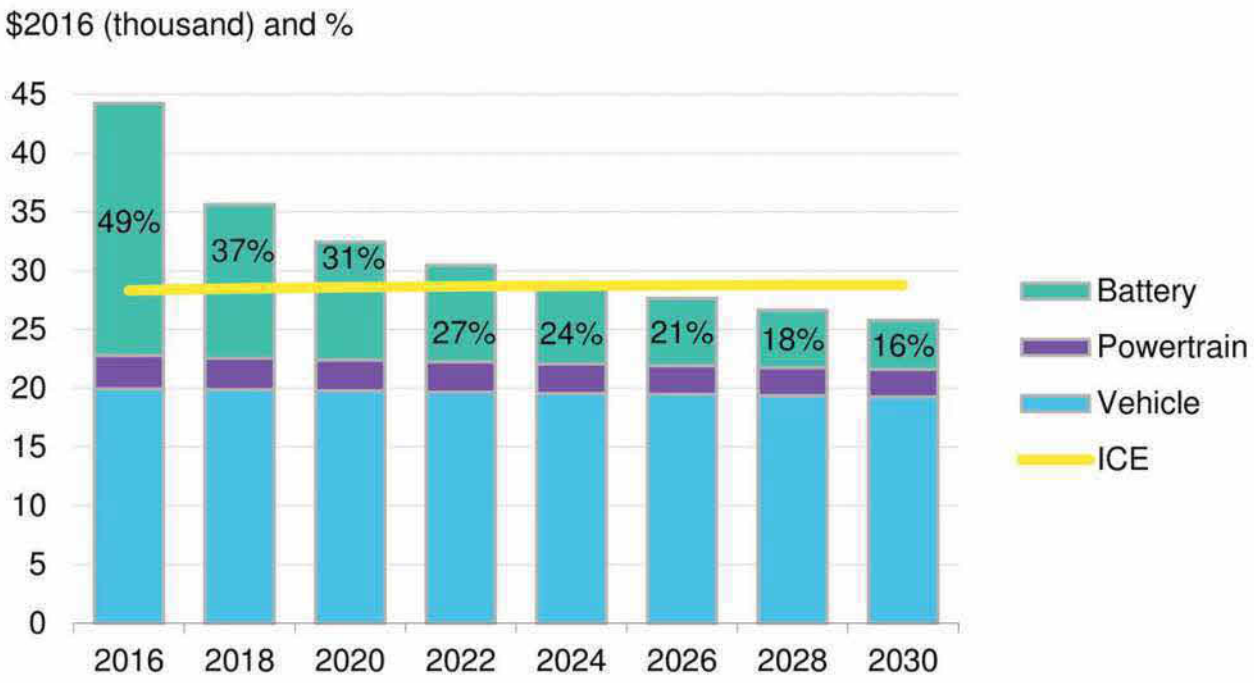

Figure 6: BNEF forecast of upfront EV prices, before incentives, suggests price parity with ICE vehicles by 2025

CUSTOMER USES FOR LIGHT-DUTY VEHICLES

There are four primary customer uses for LDVs, described below. Adoption barriers and grid integration challenges for each use case are discussed individually in the following section.

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[22] Section 177 of the federal Clean Air Act (42 U.S.C. Sec. 7507) permits states to adopt California's tailpipe emissions standards instead of the less stringent federal standards. Current ZEV States in addition to California are Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, Oregon and Colorado.

[23] Bloomberg New Energy Finance, (2017). "All Forecasts Signal Accelerating Demand for Electric Cars" Available at: https://about.bnef.com/blog/forecasts-signal-accelerating-demand-electric-cars/.

[24] Bloomberg New Energy Finance, "Electric Vehicle Outlook 2019," Available at: https://about.bnef.com/electric-vehicle-outlook/.

[25] McKinsey & Company, "Making electric vehicles profitable," March 2019. Available at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/making-electric-vehicles-profitable.

[26] Bloomberg, "Electric Car Price Tag Shrinks Along with Battery Cost," April 12, 2019. Available at: https://www.bloomberg.com/opinion/articles/2019-04-12/electric-vehicle-battery-shrinks-and-so-does-the-total-cost.

Personal vehicles are owned by individuals or families and account for most LDV sales and vehicle miles travelled (VMT) today. These vehicles are typically used for commuting, errands and occasional longer trips.

Networked service vehicles include taxis, limousines and vehicles affiliated with TNCs like Lyft and Uber. These service vehicles generally have high VMT, increasing the savings from EVs' lower maintenance and refueling costs.

Shared vehicles include those in car-share and rental fleets. Trips taken in these shared vehicles are typically local and short. The brief uses of these vehicles by a large number of individuals provides an opportunity to increase EV awareness.

Fleet vehicles include numerous public and private vehicle fleets that operate in Arizona, which vary widely in annual VMT and range of operation. High-mileage fleets are strong candidates for electrification as the total cost of ownership declines with increased VMT.

CHARGING INFRASTRUCTURE FOR LIGHT-DUTY VEHICLES

All light-duty EVs can charge at AC power using J1772 connectors, which have been standardized in the U.S. market. Most BEVs are also equipped with a DC fast charging port. There are three main standards for DC charging — CHAdeMo (used by Japanese automakers), Combined Charging System (CCS, used by European and U.S. automakers) and Tesla's proprietary supercharger technology. Note that Tesla owners may also purchase a CHAdeMO adapter. Across Arizona there are currently 417 public Level 2 charging stations hosting 985 plugs and 63 DC fast charging (DCFC) stations hosting 285 plugs.[27] Of these, over 100 stations hosting nearly 400 plugs are operated by Tesla and are therefore not accessible to non-Tesla EVs.[28]

BARRIERS TO ADOPTION

LDVs used in the four customer applications share similar adoption barriers, although they manifest in different ways.

[27] U.S. Department of Energy, "Alternative Fueling Station Locator." Available at: https://afdc.energy.gov/stations/#/find/nearest?fuel=ELEC.

[28] This includes 83 Tesla Level 2 stations hosting 184 plugs and 20 Tesla Supercharger DCFC stations hosting 194 plugs.

Lack of Awareness, Knowledge, Enthusiasm for EVs

National surveys have found widespread lack of knowledge of the commercial availability of EVs, purchase incentives, fuel and maintenance cost savings, charging options, and their ability to meet most peoples' daily driving needs.[29,30]

Lack of Suitable Models

Most of the light-duty EVs on the market today are sedans, which meet the needs of many drivers but are ill-suited for others. For instance, some LDV drivers are only willing to consider purchasing an all-electric vehicle if it is able to drive 300 miles on a single charge.[31] Additionally, those who prefer trucks or SUVs currently have limited options. However, automakers plan to begin selling approximately 130 EV models by 2023, with an average BEV range of over 250 miles.[32] Notably, the new offerings will include a number of SUVs and crossovers from both luxury and more affordable brands, as well as several pickup trucks. These are important developments since SUVs and pickup trucks made up 49% of light-duty vehicle registrations in Arizona in 2018.[33] Model availability in Arizona may lag that of the ZEV states, however, as automakers have an incentive to concentrate vehicles and marketing resources in the areas where they face regulatory obligations to greatly increase EV sales.

Insufficient Charging Infrastructure

Insufficient availability of suitable and reliable charging infrastructure is a significant barrier to adoption across all four applications of light-duty EVs.

> ***Personal vehicles:*** To date, most EV purchasers live in single-family residences and do the majority of their charging at home. A recent FleetCarma study commissioned by Salt River Project (SRP) found that roughly 75% of personal LDV charging takes place at home. However, as noted by several parties during the ACC EV Stakeholder Meetings in March 2019, home charging is an elusive option for residents of multi-unit dwellings (MUDs), which are estimated to comprise 30% of Phoenix area housing units and 31% of housing units statewide.[34,35] It is costly and complex to

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[29] National Renewable Energy Laboratory, Singer, M., "The Barriers to Acceptance of Plug-in Electric Vehicles: 2017 Update," NREL Technical Report: NREL/TP-5400-70371. Available at: https://www.nrel.gov/docs/fy18osti/70371.pdf.

[30] International Council on Clean Transportation, Jin, L. and Peter, S., "Literature of electric vehicle consumer awareness and outreach activities," March 21, 2017. Available at: https://www.theicct.org/sites/default/files/publications/Consumer-EV-Awareness_ICCT_Working-Paper_23032017_vF.pdf.

[31] National Renewable Energy Laboratory, Singer, M., "The Barriers to Acceptance of Plug-in Electric Vehicles: 2017 Update," NREL Technical Report: NREL/TP-5400-70371. Available at: https://www.nrel.gov/docs/fy18osti/70371.pdf.

[32] Electric Power Research Institute, "Overview of EV Market and PHEV Technology," July 8, 2019.

[33] Alliance of Automobile Manufacturers, "Autos Drive Arizona Forward," 2019. Available at: https://autoalliance.org/in-your-state/AZ/.

[34] U.S. Census Bureau, "Household Type by Units in Structure - American Community Survey 1-year estimates," 2018. Available at: https://censusreporter.org/data/table/?table=B11011&geo_ids=31000US38060&primary_geo_id=31000US38060.

[35] Ibid.

install Level 1/Level 2 in MUDs.[36] Challenges include the cost of upgrades to wiring and electrical capacity and for construction to accommodate chargers (e.g., trenching if parking is not close enough to electric infrastructure). Other concerns for building owners are the potential loss of parking spots for other vehicles and how to allocate ongoing maintenance costs. Limited availability of charging at workplaces (Level 1 or Level 2) and scarce public DCFC leave both MUD residents and other EV owners without a dependable non-home charging solution.

Even for customers who can charge at home, a robust and reliable network of public chargers, especially DCFC, is essential to building range confidence and enabling EVs to serve the same needs as provided by conventional personal vehicles. Beyond Tesla's private network, EVgo, Blink and Electrify America currently have the largest populations of DCFCs in Arizona.[37] While the DCFC network in Arizona has been growing, this system will need to expand significantly to meet forecast EV growth. For example, the recent Navigant EV adoption study found that the number of DCFC ports in APS territory will need to increase four-fold by 2038 in the base adoption scenario, and by more than ten-fold in the market transformation scenario.[38] Elsewhere, utilities and/or governments have stepped in to help fill the gap.

Electric taxis and TNC vehicles: Electric taxis and TNC vehicles need access to a reliable and relatively uncongested network of public DCFC so they can recharge swiftly and return to service. TNCs report that their EV growth strategy is to first move into markets with existing DCFC infrastructure that is sufficiently available to their drivers before potentially investing in or partnering to develop more dedicated charging stations.

Shared vehicles for personal use: Car-share vehicles are typically used for short-duration, short-distance trips, creating opportunities to recharge at a depot. Rental cars need to be able to recharge quickly at or near the depot in order to return to service quickly. They also require a sufficiently robust charging network at destination points (e.g., tourist attractions, resorts, restaurants, retail establishments) for rental car companies to put them in their fleets and for customers to be willing to drive them.

Fleet vehicles: These vehicles mainly need to be able to charge at their depot. Overnight charging is likely suited for most fleets, although driving patterns vary widely. There may be a need for public DCFC to extend the range of vehicles that routinely drive long distances.

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[36] California Air Resources Board, Waters, D., "Electric Vehicle (EV) Charging Infrastructure: Multifamily Building Standards," April 13, 2018. Available at: https://arb.ca.gov/cc/greenbuildings/pdf/tcac2018.pdf.
[37] U.S. Department of Energy, "Electric Vehicle Charging Station Locations." Available at: https://afdc.energy.gov/fuels/electricity_locations.html.
[38] Navigant Consulting, "Electric Vehicle Adoption Forecast and Charging Station Siting Analysis: Arizona Public Service," October 2, 2019.

Cost Premium Versus Conventional Vehicles

Cost premiums are an issue for all light-duty applications. Figure 7 depicts the differences in manufacturer's suggested retail price (MSRP) values of light-duty EVs and their conventional vehicle counterparts, highlighting the upfront cost premium. The chart also shows that many of today's EVs are costly luxury makes and models.

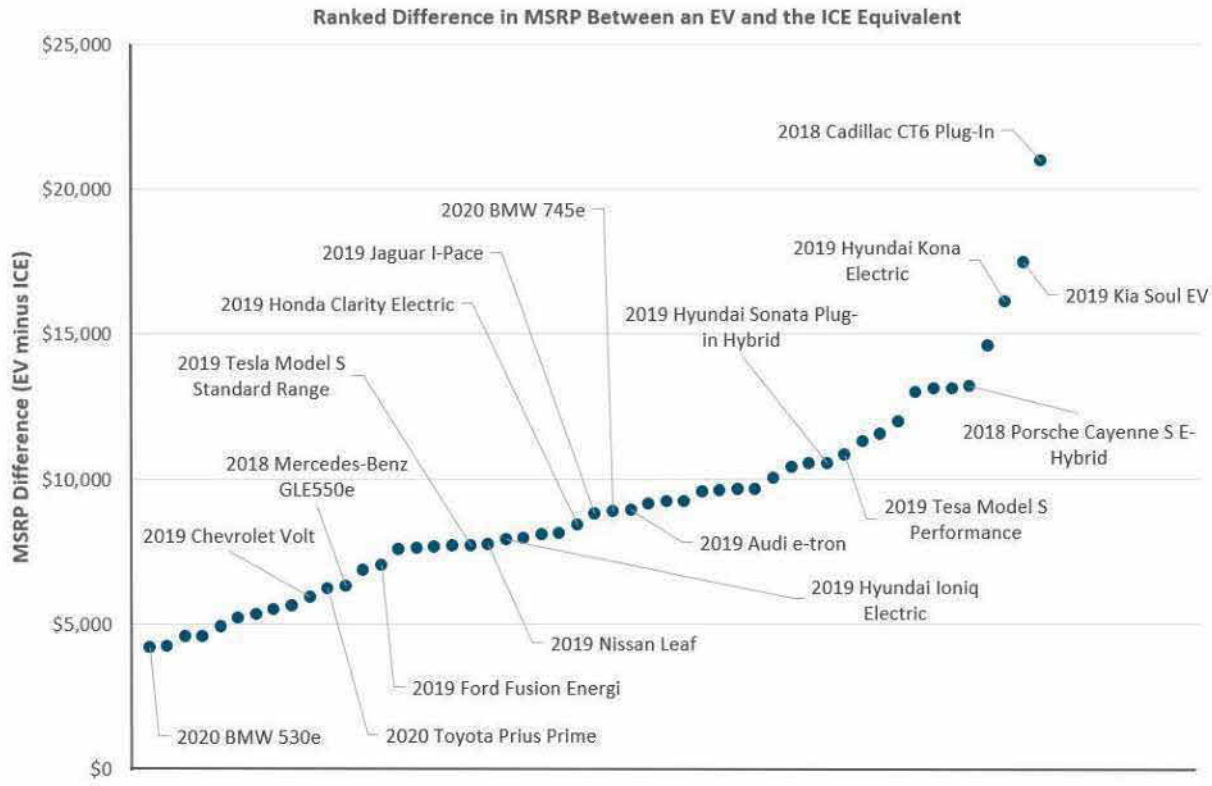

Figure 7. Differences in MSRP between EV models (before accounting for tax credits) and their standard internal combustion engine counterparts[39]

Though numerous EV cost-benefit analyses such as the recent study by MJ Bradley (commissioned by the Southwest Energy Efficiency Project (SWEEP) and Western Resource Advocates (WRA)) reveal net economic benefits to the average EV driver, this is based on total cost of ownership (TCO) over the vehicle's life rather than on upfront cost. The upfront cost premium remains a barrier even for EVs with lower TCO than their conventional counterparts, given that TCO requires consumers to factor in charger costs, tax credits, gasoline savings and electricity prices, which can be a challenging sales pitch versus the more familiar calculations for ICE vehicles. Declining upfront EV costs could help overcome this barrier, as can online calculators such as the one under development by TEP.

[39] PG&E, "Compare Electric Vehicles," 2019. Available at: https://ev.pge.com/vehicles.

Introducing EVs into shared and TNC fleets will accelerate availability of relatively inexpensive secondhand EVs and provide more Arizona residents the opportunity to own one. These vehicles are generally re-sold once they reach a certain mileage, which occurs more quickly for these heavily utilized fleets than would be the case for most private vehicles. This opportunity will expand once automakers begin producing stripped down basic models of EVs for such fleets, an option currently available only for conventional models.

Lack of Dealer Incentives to Sell EVs

Vehicle shoppers' experiences at the dealership may deter them from choosing an EV, especially if they are not already aware of their availability and advantages. Research shows that car dealerships may perceive a lack of business case viability relative to conventional vehicles, leading to dealers being dismissive of EVs, misinforming shoppers on vehicle specifications, and/or omitting EVs from the conversation entirely.[40,41] There is also a perception that dealers may be reluctant to sell EVs as their lower maintenance costs mean less business and profit for their repair shop. These issues mainly affect purchasers of personal vehicles.

GRID INTEGRATION CHALLENGES AND OPPORTUNITIES

As more EVs come online, utilities face the challenge of integrating them proactively and cost-effectively onto their distribution systems. Personal EVs have so far been largely charged at home. Absent incentives for drivers to shift their charging behavior, the average driver is likely to plug into a Level 1 or Level 2 charging port when returning home from work or school. This means that without incentives, residential EV charging will likely be highly coincident with evening distribution system peak loads. In addition, power levels for public DC fast charging are steadily rising with EVSPs beginning to install EVSE with capacities up to 350 kW, as noted by Electrify America during the March EV Stakeholder Meetings at the ACC. Especially if grouped together in charging plazas, these large-capacity chargers can trigger distribution system upgrades. [42,43]

Incentivizing "smart" charging of EVs using TOU rates, data readers like FleetCarma or direct control demand response programs can avoid or delay the need for distribution upgrades, lowering utility costs and customers' bills. EVs can also provide grid services that increase the reliability of the grid and assist with renewable integration. For example, workplace charging could provide the ability to absorb low-cost peak solar generation from the Energy Imbalance Market, lowering utility costs. Automakers, charging providers and technology companies are developing technologies to aggregate individual EVs and fleets

[40] Nature Energy, de Rubens, G., Noel, L., and Sovacool, B., "Dismissive and deceptive car dealerships create barriers to electric vehicle adoption at the point of sale," May 21, 2018.
[41] Sierra Club, "Rev Up Electric Vehicles: Multi-State Study of the Electric Vehicle Shopping Experience," 2016. Available at: https://content.sierraclub.org/evguide/rev-up-evs.
[42] UtilityDive, "Uncoordinated trouble? Electric vehicles can be a grid asset, but only with planning and investments," January 31, 2018. Available at: https://www.utilitydive.com/news/uncoordinated-trouble-electric-vehicles-can-be-a-grid-asset-but-only-with/515787/.
[43] Electrify America, "National ZEV Investment Plan: Cycle 2," February 4, 2019. Available at: https://www.epa.gov/sites/production/files/2019-02/documents/cycle2-nationalzevinvestmentplan.pdf.

to provide grid services, including capacity, replacement reserves, regulating reserves and fast frequency response.

Buses

Bus electrification represents an important medium-term opportunity in Arizona. These vehicles present distinct challenges from those of the LDV segment given differences in size, usage and technology maturity, yet nonetheless represent a market segment which is increasingly ripe for electrification.

MATURITY, ADOPTION AND MARKET SIZE

Buses come in many shapes and sizes but fall generally into four categories: *Transit*, *Tourist*, *School* and *Shuttle*. Both transit and shuttle e-buses have reached the commercial stage.

While transit e-bus manufacturing is dominated by Chinese firms, competition from U.S. and European manufacturers is growing: all major North American bus makers are producing full-sized battery-electric transit buses, and over 25 different models are now available in the U.S.[44] As transit agencies across the country increasingly adopt electric buses Arizona will be able to learn from their experiences with new technologies.[45]

In many parts of the country electrified transit buses already offer TCO savings over diesel and compressed natural gas (CNG) buses. Bloomberg New Energy Finance predicts electric buses will reach upfront price parity with diesel buses by 2030,[46] and Navigant expects electric buses to comprise 27% of new U.S. bus sales by 2027.[47] Recent reports from communities piloting electric transit or school bus programs have also been promising, with the buses largely meeting or exceeding expectations.[48]

Buses may charge at a depot or, to maintain continuous operation, stop briefly at ultra-fast overhead chargers (pantographs) situated along their route. Wireless or inductive charging allows vehicles to charge while driving a short, fixed route or while parked.

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[44] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives," Appendix D, September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.

[45] For example, in late 2018 CARB approved a regulation mandating that California's transit agencies transition to 100% zero-emission bus fleets by 2040. Other cities and transit agencies have also committed to zero-emission transit bus fleets, including New York City and King County Metro (Seattle).

[46] Bloomberg New Energy Finance, "Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO2," April 10, 2018. Available at: https://about.bnef.com/blog/electric-buses-cities-driving-towards-cleaner-air-lower-co2/.

[47] Navigant Research, "Market Data: Electric Trucks and Buses," 2018. Available at: https://www.navigantresearch.com/reports/market-data-electric-drive-buses.

[48] U.S. Public Interest Research Group, "Electric Buses in America: Lessons from Cities Pioneering Clean Transportation," October 2019. Available at: https://uspirg.org/feature/usp/electric-buses-america#.

Electrified school buses are also beginning to reach the market[49] and are already being piloted in several communities in the U.S. and Canada.[50,51,52,53,54] The more mature electric school bus manufacturers include Lion, Blue Bird, Green Power, Starcraft and Trans Tech. This technology may get a boost from the Volkswagen settlement. States have broad latitude in spending the NO_X mitigation funds allocated to them in the Volkswagen Environmental Mitigation Trust, and many have expressed an interest in electrifying school buses to capture the added benefit of reducing children's exposure to toxic air contamination from emissions of diesel particulate matter.[55] In Arizona, however, school systems have primarily used these funds to upgrade to new diesel buses.[56]

BARRIERS TO ADOPTION

Arizona presents a challenging environment for bus electrification. Some pilots have found that in hot climates e-buses require larger-capacity batteries than are currently available to serve their high air-conditioning requirements while also delivering the mileages needed to cover their routes.

Recent trials of electric buses in regions with hills or high AC demands demonstrate that the electric bus technology still needs improvement.[57,58,59] A local example comes from the Phoenix area's Valley Metro, which reported that its 2016 pilot with a BYD electric bus proved unsuccessful due to the limited range of the vehicle in Arizona's hot climate. The bus was unable to surpass a 90-mile range (less than two-thirds of the bus's advertised range), making it unfit for most of the agency's current routes. Valley Metro

[49] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives" Appendix E, September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.
[50] Acadia Center, "No. 1 on Our List of Back to School Supplies: Electric School Buses," September 6, 2017. Available at: http://acadiacenter.org/no-1-on-our-list-of-back-to-school-supplies-electric-school-buses/.
[51] School Transportation News, "Largest US Electric School Bus Pilot Comes to California," May 12, 2017. Available at: https://stnonline.com/news/largest-us-electric-school-bus-pilot-comes-to-california/.
[52] Energy New Network, "Minnesota district to get Midwest's first electric school bus this fall," July 11,2017. Available at: https://midwestenergynews.com/2017/07/11/minnesota-district-to-get-midwests-first-electric-school-bus-this-fall/.
[53] Ontario Ministry of Transportation, "Electric School Bus Pilot Program," August 28, 2017. Available at: http://www.mto.gov.on.ca/english/vehicles/pdf/electric-school-bus-webinar-deck.pdf.
[54] Vermont Energy Investment Corporation, "Bring electric school buses to your district." Available at: https://www.veic.org/electric-school-buses.
[55] California Air Resources Board, "Overview: Diesel Exhaust and Health." Available at: https://www.arb.ca.gov/research/diesel/diesel-health.htm.
[56] AZ.gov, "Volkswagen Settlement." Available at: https://vwsettlement.az.gov/.
[57] Reuters, Groom, N., "U.S. transit agencies cautious on electric buses despite bold forecasts," December 11, 2017. Available at: https://www.reuters.com/article/us-transportation-buses-electric-analysi/u-s-transit-agencies-cautious-on-electric-buses-despite-bold-forecasts-idUSKBN1E60GS.
[58]South Florida Sun Sentinel, "Electric buses: Can they take the (South Florida) heat?" November 2, 2018. Available at: https://www.sun-sentinel.com/news/transportation/fl-ne-electric-buses-will-they-hold-up-20181025-story.html.
[59] Los Angeles Times, "Stalls, stops and breakdowns: Problems plague push for electric buses," May 20, 2018. Available at: https://www.latimes.com/local/lanow/la-me-electric-buses-20180520-story.html.

remains optimistic about future electric bus technologies and is willing to reconsider them after they are further proven in other regions.[60]

Other common barriers cited are knowledge of and/or enthusiasm about electric models among bus operators, the capital cost premium over conventional alternatives (CNG and diesel), and the existing electricity rate structures available today. Additional barriers include:[61]

- Scalability without grants and incentives
- Flexibility and operational experience
- The expectation that costs will decline leading operators to defer transitioning their fleets
- Low load factor during early bus deployment, leading to high customer demand charges per bus
- Interconnection issues and need for grid upgrades
- Lack of standardized charging infrastructure

GRID INTEGRATION CHALLENGES AND OPPORTUNITIES

Integrating e-buses into the grid presents both challenges and opportunities, which vary across the four bus categories. Typical e-bus loads are currently as much as 500 kW using an overhead charger and 100 kW using a depot charger.[62] A recent E3 analysis found bus depot loads ranged from 0.5 MW to 40 MW depending on assumptions regarding bus fleet electrification levels, charging schedules, bus-to-charger ratios, and charger sizes. This type of load is comparable to 200 to 16,000 typical homes in the U.S. As it is unlikely that depots can be relocated to uncongested parts of the grid, it will be necessary to coordinate distribution system upgrades with bus operators' plans to electrify their fleets.

Demand charges for bus electrification stem from the poor load factor that comes from inconsistent charging times, charging over peak and brief but high levels of charging. Due to the need to design rates based on cost of service, this particular type of load can impose additional system costs if bus charging loads are not managed by the bus depot or the utility.

School buses could present a unique opportunity to create a new daytime load as they are usually idle during school hours and could charge mostly or entirely on solar power. Their large batteries of 150 – 200

[60] Based on conversations with Valley Metro on 1/9/19 and 2/1/19.
[61] Bloomberg New Energy Finance, "Electric Buses in Cities: Driving Towards Cleaner Air and Lower CO2," April 10, 2018. Available at: https://about.bnef.com/blog/electric-buses-cities-driving-towards-cleaner-air-lower-co2/.
[62] CALSTART, Gallo, J., Bloch-Rubin, T., and Tomic, J., "Peak Demand Charges and Electric Transit Buses: White Paper," October 1, 2014. Available at: https://calstart.org/wp-content/uploads/2018/10/Peak-Demand-Charges-and-Electric-Transit-Buses.pdf.

kWh are also potential sources of ancillary services. A number of school districts across the country are currently conducting vehicle-to-grid (V2G) pilots for school e-buses.[63,64,65,66]

Micromobility[67]

MATURITY, ADOPTION AND MARKET SIZE

Currently, over 75% of Arizona commuters drive alone to work, while roughly 1% bike.[68] However, electrification of small personal mobility devices is rapidly advancing, providing an alternative option for workers with shorter commutes. Benefits of these devices (e-bikes, e-scooters and e-mopeds) include reduced carbon emissions, noise pollution and local air pollution. Electric scooters in particular have provoked controversy and have been subject to a range of policy measures in cities where they have been introduced. Tempe, Scottsdale, Peoria and Mesa have welcomed them, while Phoenix has been more hesitant to allow them, and Tucson is exploring their impact on mobility and public safety. The Phoenix City Council recently approved a six-month pilot program for three scooter vendors to offer their services within a specific area of the city, which will run until March 2020, before officially making a decision on the viability of scooters in the city.[69] Tucson is also in the midst of a six-month pilot program with two scooter vendors, which includes discounted pricing for low-income residents.[70] Scottsdale incorporated scooters into its bicycle ordinance, and has placed limits on where they may be parked.[71] Tempe requires these e-mobility companies to sign a licensing agreement in order to operate within their city limits, which details certain operational and safety standards that must be met.[72]

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[63] CleanTechnica, "Massachusetts Puts $1.4 Million Into Electric School Bus Pilot," August 16, 2016. Available at: https://cleantechnica.com/2016/08/16/massachusetts-puts-1-4-million-electric-school-bus-pilot-project/.

[64] PJM Inside Lines, "V2G Hits the Big Time with Dominion Electric School Bus Project," October 10, 2019. Available at: https://insidelines.pjm.com/dominion-to-roll-out-largest-electric-school-bus-deployment-in-u-s/.

[65] Electrek, "Electric V2G school bus pilots grow, but schools asleep at the wheel," August 23, 2019. Available at: https://electrek.co/2019/08/23/electric-v2g-school-bus-pilots-grow/.

[66] Greentech Media, "School Districts Rolling Out Electric Buses as Economics Improve: 'It's Time to Switch'," November 15, 2018. Available at: https://www.greentechmedia.com/articles/read/school-districts-rolling-out-electric-buses.

[67] Micromobility is "a catch-all term for several modes of transportation, namely docked and dockless bikeshare systems, electric bikes and electric scooters." – National League of Cities, "Micromobility in Cities: A History and Policy Overview," April 25, 2019. Available at: https://www.nlc.org/sites/default/files/2019-04/CSAR_MicromobilityReport_FINAL.pdf.

[68] Arizona Department of Transportation, "Transportation in Arizona," January 2016. Available at: https://azdot.gov/sites/default/files/2019/08/final-transportation-in-arizona-working-paper-1_15_2016.pdf.

[69] City of Phoenix, "E-Scooter Pilot Program." Available at: https://www.phoenix.gov/streets/scooters.

[70] City of Tucson, "E-Scooter Pilot Program." Available at: https://www.tucsonaz.gov/bicycle/e-scooter-pilot-program.

[71] AZFamily.com, "Scottsdale releases strict rules for electric scooters," December 13, 2018. Available at: https://www.azfamily.com/news/scottsdale-releases-strict-rules-for-electric-scooters/article_1b07e0ce-ff12-11e8-ba8d-1f3887acdbf3.html.

[72] City of Tempe, "Tempe passes license to regulate scooter and dockless bike companies," January 11, 2019. Available at: https://www.tempe.gov/Home/Components/News/News/13258/.

BARRIERS TO ADOPTION

The primary barriers to adoption of these personal mobility devices are customer awareness, avoiding nuisance parking, and safety concerns.

GRID INTEGRATION CHALLENGES AND OPPORTUNITIES

These devices charge at Level 1 and do not require specialized charging equipment. Like personal LDVs, this charging load likely has significant flexibility that can be harnessed to enable cost-effective grid integration and support renewable energy.

Goods Movement

Arizona's economy relies heavily on freight. The Arizona Department of Transportation (ADOT) reports that freight-dependent sectors account for 30% of state GDP and 32% of jobs.[73] Of the state's freight tonnage, over 65% is carried by truck. The majority of this freight value is moving *through* the state, largely due to traffic between the Ports of Long Beach and Los Angeles and inland markets via I-10 and I-40. Passing through both Phoenix and Tucson, I-10 is a critical component of Arizona's freight system. Additionally, two of the nation's four transcontinental freight rail corridors traverse Arizona, and most of the non-trucking freight is transported by rail (again with the majority of rail tonnage moving *through* the state). Intermodal transfer facilities in Phoenix and Tucson provide the capability to transfer freight between trucks and rail cars.

With six of the 29 land crossings between the U.S. and Mexico, a significant portion of trading value passes through Arizona. Of the $437 billion worth of goods moving across land borders between the two countries in 2014, $30 billion (7%) was processed by Arizona border crossings. Of the value crossing Arizona's borders, $20 billion was handled by trucks, with the majority of the remainder transported by rail. Land-based border flows are heavily concentrated at two crossings: over 85% of both imports and exports flow through Nogales-Nogales, while over 10% of both imports and exports flow through Douglas-Agua Prieta.

ADOT anticipates freight flows in Arizona increasing in the coming years.[74] Population growth and the increasing popularity of e-commerce are generating more local truck trips to deliver parcels. Meanwhile, local economic growth and complex supply chains are leading to more movement of final and intermediate goods in and out of the region, especially to Mexico. This increased freight traffic – from both trucks and trains – will result in increased diesel emissions. With the Phoenix/Mesa area already in *Serious* and *Moderate* Non-attainment of the federal NAAQS for PM_{10} and Ozone, respectively, reducing diesel emissions from goods movement is becoming a priority, especially given that recent data shows ozone concentrations in the area have continued to rise in recent years.[75] While efforts to date have

[73] Arizona Department of Transportation, "Arizona State Freight Plan A to Z," 2017. Available at: https://azdot.gov/sites/default/files/2019/08/arizona-state-freight-plan-110917.pdf.
[74] Ibid.
[75] Arizona Department of Environmental Quality, "RE: Possible Modifications to ACC's Energy Rules," May 20, 2019.

focused on idling limits and voluntary replacement of older diesel vehicles,[76,77] electrified options are increasingly available and approaching commercialization for many of the types of vehicles and equipment involved in freight handling, and may therefore provide additional mitigation pathways.

The remainder of this section summarizes the current state of electrified goods movement technologies and describes the barriers to deployment and grid integration challenges and opportunities. Trucks are discussed in the greatest detail, with less focus on other technologies. Consideration of rail transportation is limited to nonroad vehicles and equipment at stationary facilities as at this time there are significant challenges to electrifying diesel trains themselves.

Medium-Duty Trucks / Vans

MATURITY, ADOPTION AND MARKET SIZE

Medium-duty (MD) trucks, especially last-mile delivery vehicles, are the most advanced electric-drive truck technology. MD trucks (Classes 4-6) range from 14,001 to 26,000 lbs., and their uses include various delivery services as well as utility service or "bucket" trucks. The relatively short, set routes of most delivery vehicles are well within the 100-mile range of current offerings. These vehicles use conductive plug-in L2 and DCFC charging infrastructure and are equipped with batteries ranging in size from 60 – 120 kWh.

Early deployments are proliferating. UPS has established partnerships with several EV startups to develop electric trucks and is beginning to deploy them in its global fleet of 119,000 vehicles. In 2018 FedEx announced that it would be acquiring 1,000 Chanje V8100 electric delivery vans,[78] while DHL, which bought an electric van company called StreetScooter in 2014, has thousands of electric delivery vans and is producing 2,500 more this year. Most recently, Amazon announced it has ordered 100,000 electric delivery vans from Rivian, a Michigan-based startup automaker that plans to debut its electric pickup truck and SUV in 2020.[79]

BARRIERS TO ADOPTION

The principal barriers to adoption of electric-drive MD trucks are awareness, the cost and lead times associated with dedicated depot chargers, and the upfront vehicle price premium relative to diesel alternatives. Highly visible early deployments by fleet giants like FedEx, UPS, Ryder and Pepsi-FritoLay are raising awareness of the availability of e-trucks. The price premium will continue to decline as battery technology improves and manufacturers realize scale economies, lowering the TCO.[80] Even with TCO

[76] Maricopa County, "Diesel Idling," May 30, 2019. Available at: https://www.maricopa.gov/1762/Diesel-Idling.
[77] City of Phoenix, "Environmental Sustainability Goals." Available at: https://www.phoenix.gov/sustainability/air.
[78] FedEx, "FedEx Acquires 1,000 Chanje Electric Vehicles," November 20, 2018. Available at: https://about.van.fedex.com/newsroom/fedex-acquires-1000-chanje-electric-vehicles/.
[79] Wired, "Amazon Puts a Charge into Startup Automaker Rivian," September 19, 2019. Available at: https://www.wired.com/story/amazon-puts-charge-startup-automaker-rivian/.
[80] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives – Appendix D" September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.

lower than conventional vehicles, smaller fleet operators may still face issues in absorbing the initial capital cost of the vehicle price premium and charging infrastructure. One manner to address upfront costs is through available Volkswagen Settlement funds: New Jersey recently awarded $825,000 to IKEA for purchase of electric delivery trucks at several locations.[81]

GRID INTEGRATION CHALLENGES AND OPPORTUNITIES

The duty cycles for these vehicles vary widely: Delivery of parcels often starts in the very early morning hours and concludes by 2 or 3 p.m., while produce delivery is often complete by 6 a.m. A number of these vehicles could therefore be available to charge using solar energy for their full six- to eight-hour charging time.

Truck Stop Electrification and Electrified Transport Refrigeration Units

Initiatives to reduce idling of conventional diesel trucks have stimulated development of systems to enable trucks to use electricity instead of running their engines while parked. Truck stop electrification (TSE), also known as electrified parking spaces, at truck stops and truck terminals provides the necessary heating, air conditioning and power for onboard appliances. Single-system electrification relies on offboard equipment, with a hose connected by a window adapter delivering HVAC services. Dual-system electrification, or "shore power," requires both onboard and offboard equipment so that trucks can plug directly into electrical outlets. Trucks must be equipped with AC equipment or an inverter to convert 120-volt power. These systems may be owned by the truck stop or by a private company that regulates use and fees.[82]

Electrified transport refrigeration units also offer opportunities to reduce vehicle idling. One pathway uses "shore power" to cool units while docked at facilities; SRP is currently offering a $1,000 rebate for eligible customers to install the required equipment. Another pathway is through on-board battery technology, which is improving and is in the early stages of deployment. For example, Thermo King, a large supplier of transport refrigeration technologies, recently announced a partnership with electric MDV company Chanje and the two companies are currently testing an all-electric refrigerated delivery van.[83]

Both of these technologies present near-term, non-LDV TE opportunities in Arizona given the state's sizeable trucking industry.

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[81] New Jersey Department of Environmental Protection, "Overview of Distribution of Mitigation Funds," November 19, 2019. Available at: https://www.state.nj.us/dep/vw/project.html.
[82] U.S. Department of Energy, "Truck Stop Electrification for Heavy-Duty Trucks." Available at: https://afdc.energy.gov/conserve/idle_reduction_electrification.html.
[83] Thermo King, "Driving Innovation: 100% Electric. 100% Cool," April 5, 2019. Available at: https://www.thermoking.com/na/en/newsroom/2019/04/driving-innovation--100--electric--100--cool--.html.

Heavy-Duty Trucks

MATURITY, ADOPTION AND MARKET SIZE

Heavy-duty (HD) trucks (Classes 7 and 8) weigh over 26,000 lbs. and include long-haul, regional freight delivery, and drayage trucks (which transfer containers from ports to warehouses). Although this segment is further from commercialization than MD trucks, recent announcements by Tesla[84], BYD[85], Cummins[86] and Volvo[87] suggest that development of electrified HD technologies is accelerating. CARB funding for demonstration projects is also helping to further develop these technologies.

BARRIERS TO ADOPTION

One of the main barriers to HD truck electrification is the high cost resulting from low production volumes, high battery cost, and the electric powertrain. Lower range limits for fully electric trucks and the associated need for frequent recharging present a barrier although they have been steadily improving with advances in battery technology. The availability of suppliers and vendors is currently limited but also increasing. Finally, demand charges in commercial and industrial electricity rates can significantly increase bills. Given these barriers, regional freight delivery and drayage services have duty cycles that are a better fit for the introduction of electric trucks. Electrifying freight transport for longer routes is likely a longer-term opportunity.

GRID INTEGRATION CHALLENGES AND OPPORTUNITIES

HD e-truck chargers draw very large loads and may require major infrastructure upgrades at depots. Power supply upgrades may be necessary as well.[88]

Nonroad Vehicles and Equipment

Electrified alternatives are available to replace most types of diesel-powered cargo-handling vehicles and equipment. Equipment for handling cargo containers includes yard hostlers that move containers within the terminal, gantry cranes that are used in intermodal operations to ground or stack containers, top handlers, side handlers, and Automated Guided Vehicles (AGVs) that move materials around a warehouse.

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[84] Trucks.com, "Here's Everything We Know About the Tesla Semi," September 5, 2019. Available at: https://www.trucks.com/2019/09/05/everything-we-know-about-the-tesla-semi-truck/.
[85] InsideEVs, "See the BYD Class 8 Electric Truck in Motion: Video," October 11, 2019. Available at: https://insideevs.com/news/375749/byd-class-8-electric-truck-in-motion/.
[86] Cummins, "PowerDrive for Electric Trucks." Available at: https://www.cummins.com/electrification/powerdrive-for-electric-trucks.
[87] Trucks.com, "Volvo Trucks Unveils Electric Truck, Readies Commercialization," September 13, 2019. Available at: https://www.trucks.com/2019/09/13/volvo-unveils-vnr-electric-truck/.
[88] Rocky Mountain Institute, "Seattle City Light: Transportation Electrification Strategy," 2019.

Several electrified cargo-handling technologies are at TRL 7-9.[89] Electrified cargo-handling technologies would be particularly helpful for freight clusters along the I-10 corridor in Phoenix and Tucson.

The light-duty electric forklifts used in warehouses have achieved commercialization and are widely used. Because they have no emissions, electric forklifts are attractive for indoor use. These forklifts are estimated to have a typical payback in less than two years, largely through reducing fuel costs by up to 75% but also by reducing maintenance costs.

A wide range of electric-powered ground support equipment (e-GSE) in airports – such as pushback tractors, belt loaders, luggage tugs, and water trucks – is available from multiple manufacturers, and a number of U.S. airports have launched significant e-GSE projects. In 2015, Phoenix's Sky Harbor airport received a Federal Aviation Administration Voluntary Airport Low Emissions Program (VALE) grant for $1 million to develop 28 charging stations for e-GSE with support from Southwest Airlines and American Airlines. This funding will replace 68 diesel-powered GSE. With the support of these airlines the Aviation Department is aiming for 100% of GSE to be zero-emissions by 2050.[90]

Tactical fleets at military bases are also prime candidates for electrification, and such investments align well with the military's dedication to energy efficiency. The Los Angeles Air Force Base was the first to experiment with V2G in collaboration with the Microgrids Group at Lawrence Berkeley National Laboratory.[91] The seven military bases in Arizona provide a number of potential electrification opportunities, including Luke Air Force Base and the Arizona Air national Guard.

While still nascent, electrified mining equipment also represents an opportunity in Arizona, and can help to improve health and safety at mining operations. Swedish manufacturer Epiroc recently launched a new line of battery-electric mining equipment and is receiving orders from customers in Australia, Canada and Finland.[92] Electrification of mining equipment is particularly useful for underground options, which typically require substantial investments in ventilation due to the use of diesel-powered equipment.

The higher cost for electrified goods handling equipment makes it challenging to develop a compelling business case for electric conversions, especially outside of non-attainment areas or without a local or corporate greenhouse gas (GHG) reduction target. Finally, payloads may be lower for some technologies due to the size and weight of the battery.

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[89] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives – Appendix D" September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.

[90] Phoenix Aviation Department Sustainability, "A Look Back Before We Take Off," 2017. Available at: https://www.skyharbor.com/docs/default-source/pdfs/sustainability/phoenix-aviation-department-sustainability---a-look-back-before-we-take.pdf?sfvrsn=39c9388_2.

[91] Lawrence Berkeley National Laboratory, "Los Angeles Air Force Base Vehicle to Grid Pilot Project," 2013. Available at: http://eta-publications.lbl.gov/sites/default/files/lbnl-6154e.pdf.

[92] Mining Metal News, "Epiroc wins several battery electric mining equipment orders," September 19, 2019. Available at: https://www.miningmetalnews.com/20190919/1302/epiroc-wins-several-battery-electric-mining-equipment-orders.

Hydrogen Fuel Cell Vehicles

Fuel cell vehicles (FCVs) and equipment are a zero-emissions alternative to EVs. FCVs also employ electric drive for propulsion, but their electricity is produced onboard via a chemical reaction between hydrogen and oxygen. Fuel cell models have been developed for light-, medium-, heavy-duty and some nonroad vehicles, all of which currently lag behind their battery-electric counterparts in technological maturity and adoption. While FCVs do have a range advantage over EVs, hydrogen refueling infrastructure development is considerably more challenging than EVSE infrastructure development. Additionally, the range gap is closing with advances in battery technology and declining costs. Currently neither battery-electric nor fuel cell vehicles are truly zero-emission, as both technologies result in upstream emissions from electricity generation and hydrogen production, respectively. Both technologies offer zero-emissions opportunities, however: electricity can be generated from renewable sources, and therefore hydrogen can also be produced using renewable energy.

Thus far FCVs have proven a successful alternative to internal combustion forklifts. FCVs are also seen as promising for long-haul trucking, which could represent an opportunity for Arizona: fuel cell electric freight truck maker Nikola Motors, which reports over 13,000 pre-orders for its vehicles, is planning a large manufacturing facility in Coolidge.[93] Major impediments to adoption across FCVs technologies are their high cost relative to conventional models, scarce public hydrogen dispensing infrastructure, and the high cost of hydrogen compared to gasoline. Other barriers include lack of understanding of the business case for FCVs (other than forklifts), limited choice of vendors and models, and an undeveloped service and support network.[94]

Automated Driving Technologies

Automated driving technologies are advancing rapidly and are already being deployed in all transportation sectors. Electrification will likely hasten deployment of automated driving technologies because connected, electric-drive vehicles are best suited for automation. Mass deployment of fully automated vehicles could radically transform personal mobility, mass transit and goods movement, reshaping urban landscapes — for better or worse.

Development and deployment of automatic driving technologies are proceeding incrementally. To map the pathway to full automation, the Society of Automotive Engineers created the classification system illustrated in Figure 8. Automakers and fleet owners are keenly interested in testing Level 4 (High Automation) as they strive to reach Level 5 (Full Automation). At Level 4, the vehicle can operate without human oversight under select conditions (e.g., on highways or in clear weather) or in specific geographic areas (e.g., on campuses or military bases). At Level 5 the AV can operate on any road under any condition

[93] InsideEVs, "Nikola Motors Announces Truck Manufacturing Plant in Arizona," March 23, 2019. Available at: https://insideevs.com/news/343547/nikola-motors-announces-truck-manufacturing-plant-in-arizona/.
[94] CARB, "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives – Appendix D" September 20, 2019. Available at: https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1.

without human oversight or input. Only at this stage is a vehicle truly driverless, making it possible to eliminate costly components such as the steering wheel, accelerator and brake pedals.

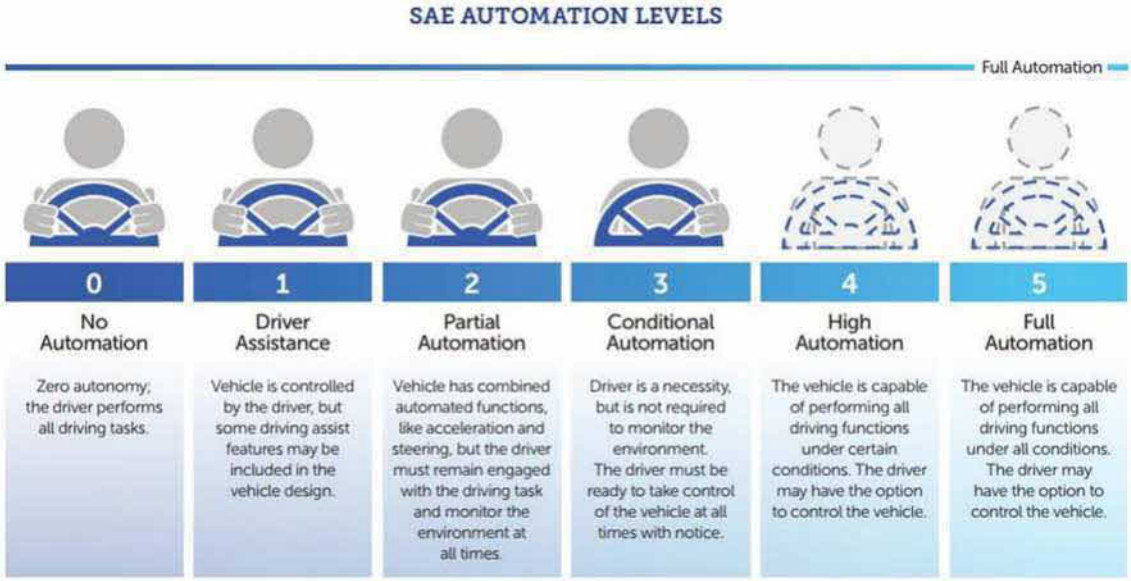

Figure 8. Levels of Vehicle Automation[95]

Automation is expected to yield many benefits, including increased safety and productivity; decreased fatalities; efficiency improvements from smoother traffic flows; and wider access to mobility.[96] Fixed route applications offer opportunities for automation, such as transit and shuttle services, bus depots, and nonroad use cases such as mines, freight handling facilities and rail yards. However, lack of standardization for charging nonroad EVs makes it challenging for utilities to anticipate their power needs.

In the LDV segment Taxi and TNC fleets are attractive early targets for automation, with significant investments being made by automakers and TNC companies alike, including Lyft, Uber, Cruise Automation, General Motors, Ford, Volvo, Honda and others. In Arizona, Google's self-driving car program, Waymo One, is available for hailing and has been reportedly moving closer to Level 5 automation.[97]

Public policy will play a key role in enabling AV testing on public roads, and Arizona is well-positioned to remain at the forefront in this area. Governor Ducey's executive orders on AVs have drawn companies developing this technology to the state, and the recently created Institute of Automated Mobility will continue to drive collaboration on AVs between the public sector, private enterprises and academia.

[95] National Highway Traffic Safety Administration, "Automated Vehicles for Safety," 2019. Available at: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety.
[96] Ibid.
[97] The Verge, "Waymo tells riders that 'completely driverless' vehicles are on the way," October 10, 2019. Available at: https://www.theverge.com/2019/10/10/20907901/waymo-driverless-cars-email-customers-arizona.

3) Transportation Electrification Policies and Institutions

While technological improvements and cost reductions have driven a large part of the increase in TE in recent years, supportive policies at the national and state level have also played a role. However, continued and expanded policy support will be critical to unlocking the benefits afforded by the opportunity to electrify the transportation sector.

Federal Policies, Regulations and Programs

Federal initiatives and policies to increase EV adoption and support can help Arizona to maximize its efforts to electrify the state's transportation sector.

FEDERAL ELECTRIC VEHICLE TAX CREDIT

The federal tax credit for plug-in EVs (PEVs) was established through the Energy Improvement and Extension Act of 2008 and was updated to its current format by the American Recovery and Reinvestment Act of 2009.[98] Credits for individual EVs range from $2,500 to $7,500, depending on battery capacity, and are subject to a 200,000-vehicle limit per manufacturer (after which credit amounts phase out over several quarters). The tax credit is not available for vehicles with a gross vehicle weight rating exceeding 14,000 pounds, and therefore excludes the majority of medium-duty and all heavy-duty vehicles.[99]

Tesla reached its 200,000-vehicle limit in June of 2018, while General Motors passed this mark in December of 2018; both of these automakers' tax credits have subsequently begun to phase out in 2019. While no other automaker has yet surpassed the 200,000-vehicle cap, as of June 2019 Nissan, Ford and Toyota had each passed the halfway-mark of 100,000 sales, while BMW had sold just over 90,000 qualified vehicles.[100] Figure 9 details qualified PEV sales by manufacturer, relative to the 200,000-vehicle limit on the federal tax credit.

[98] Congressional Research Service, "The Plug-In Electric Vehicle Tax Credit," May 14, 2019. Available at: https://fas.org/sgp/crs/misc/IF11017.pdf.

[99] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, "Qualified Plug-In Electric Vehicle (PEV) Tax Credit." Available at: https://www.energy.gov/eere/electricvehicles/electric-vehicles-tax-credits-and-other-incentives.

[100] EVAdoption, "Federal EV Tax Credit Phase Out Tracker by Automaker," 2019. Available at: https://evadoption.com/ev-sales/federal-ev-tax-credit-phase-out-tracker-by-automaker/.

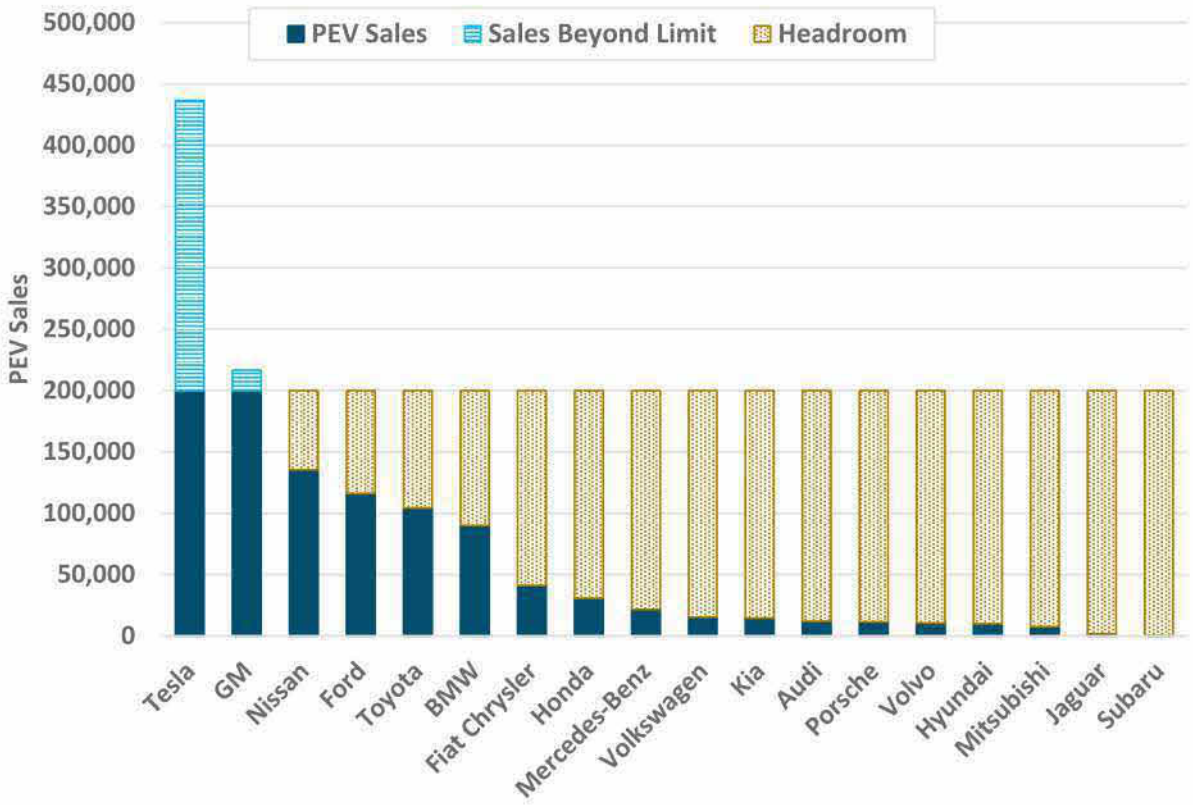

Figure 9: Federal EV Tax Credit Tracking by Automaker (through June 2019) [101]

Competing legislative proposals have recently been put forth, to either expand or repeal the EV tax credit.

- The Electric CARS Act of 2019 proposes to extend the credit through 2029 and repeal the per-manufacturer cap.[102]
- The Driving America Forward Act would increase the cap, providing tax credits of up to $7,000 for vehicles from manufacturers exceeding the 200,000-vehicle limit; these additional credits would be available for an additional 400,000 vehicles per-manufacturer.[103]
- The Fairness for Every Driver Act proposes to repeal the federal EV tax credit and to impose an annual fee on alternative fuel vehicles to contribute to the Highway Trust Fund.[104]

The Congressional Research Service reports that the federal EV tax credit is disproportionately claimed by higher-income taxpayers, with 78% of credits claimed by filers with annual adjusted gross income of

[101] Adapted from EVAdoption, "Federal EV Tax Credit Phase Out Tracker by Automaker," 2019. Available at: https://evadoption.com/ev-sales/federal-ev-tax-credit-phase-out-tracker-by-automaker/.
[102] H.R. 2042, 116th Congress (2019-2020).
[103] S. 1094, 116th Congress (2019-2020).
[104] S. 343, 116th Congress (2019-2020).

$100,000 or more.[105] As Arizona develops and expands upon its own EV initiatives, it will be critical to ensure programs and incentives are available for Arizonans of all income classes.

NATIONAL AMBIENT AIR QUALITY STANDARDS

The federal Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment.[106] The EPA in turn requires states to develop Infrastructure State Implementation Plans (SIPs) detailing how areas will attain and maintain the mandatory local air quality standards.[107] Arizona Revised Statutes (ARS), Title 49, divides responsibility and encourages cooperation for meeting the requirements of the CAA among the state, county agencies, and regional planning organizations. Currently, the state and three county agencies operate air quality control programs under direct or delegated authority. These air pollution control agencies are: the Arizona Department of Environmental Quality (ADEQ), Maricopa County Air Quality Department (MCAQD), Pima County Department of Environmental Quality (PDEQ), and the Pinal County Air Quality Control District (PCAQCD).[108]

As of October 2019, parts of Arizona were in nonattainment of five of the six criteria air pollutants regulated under NAAQS, as detailed in Table 3 and Figure 10 below. The majority of the nonattainment areas are within Maricopa and Pinal counties.

[105] Congressional Research Service, "The Plug-In Electric Vehicle Tax Credit," May 14, 2019. Available at: https://fas.org/sgp/crs/misc/IF11017.pdf.
[106] U.S. Environmental Protection Agency, "NAAQS Table." Available at: https://www.epa.gov/criteria-air-pollutants/naaqs-table#3.
[107] U.S. Environmental Protection Agency, "NAAQS Implementation Process." Available at: https://www.epa.gov/criteria-air-pollutants/naaqs-implementation-process.
[108] Arizona Department of Environmental Quality, "Arizona State Implementation Plan Revision under Clean Air Act Sections 110(a)(1) and 110(a)(2) for the 2015 Ozone National Ambient Air Quality Standards," September 24, 2018. Available at: https://static.azdeq.gov/aqd/sip/2015_o3_isip.pdf.

Table 3: NAAQS Nonattainment Areas in Arizona[109]

County	Nonattainment Area	Criteria Pollutant(s)
Cochise	Paul Spur/Douglas	PM_{10}
Gila	Miami	PM_{10}, SO_2
	Hayden	PM_{10}, Lead
Maricopa	Phoenix	PM_{10}, Ozone
Pinal	Hayden	PM_{10}, SO_2, Lead
	West Pinal	PM_{10}
	Miami	PM_{10}
Pima	Ajo	PM_{10}
	Rillito	PM_{10}
Santa Cruz	Nogales	PM_{10}, $PM_{2.5}$
Yuma	Yuma	PM_{10}, Ozone

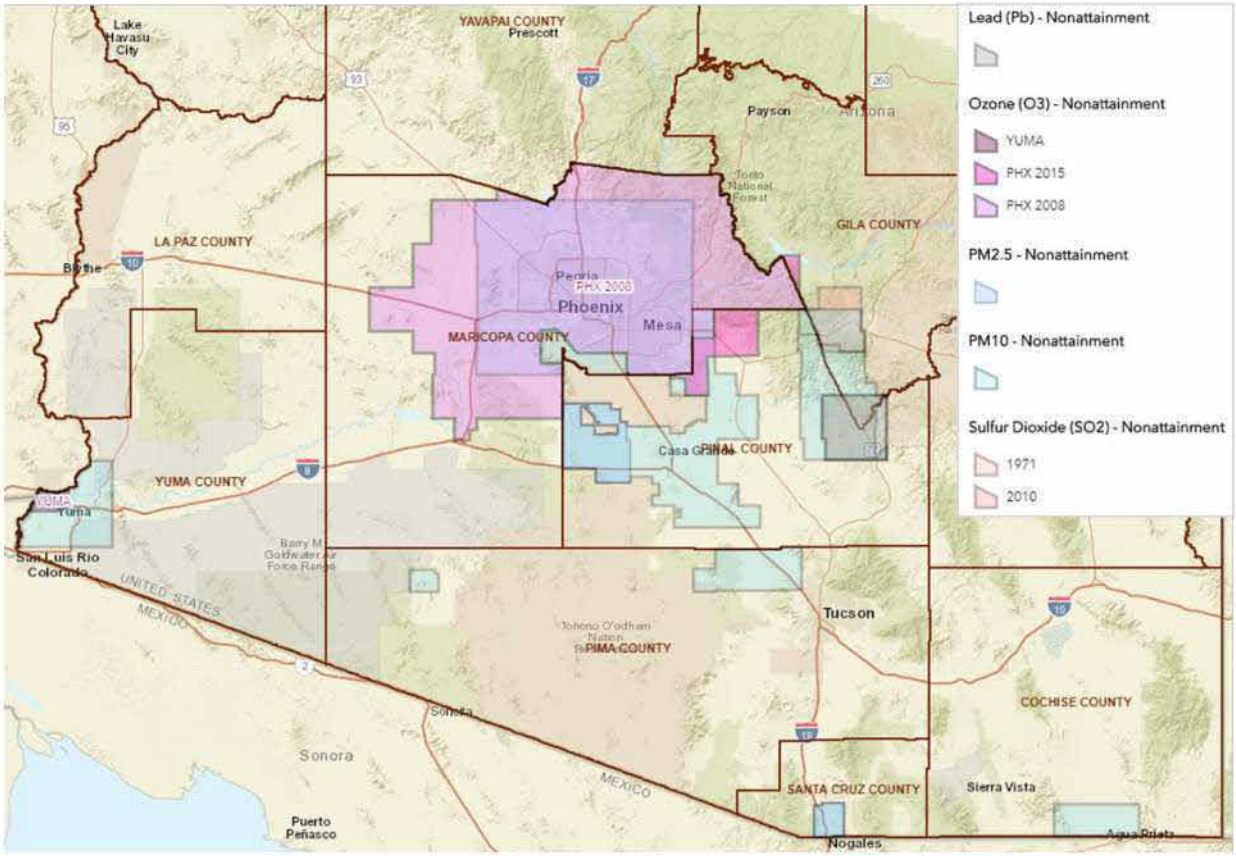

Figure 10: NAAQS Nonattainment Areas in Arizona[110]

[109] Arizona Department of Environmental Quality, "Air Quality | Nonattainment Areas," revised on October 18, 2019. Available at: https://azdeq.gov/nonattainment_areas.

[110] Arizona Department of Environmental Quality, "Non-attainment Areas." Available at: http://www.azdeq.gov/emaps.

Ozone Nonattainment

There are currently two ozone nonattainment areas in Arizona: Maricopa County and Yuma County. Ground-level ozone is regulated through nonattainment areas under the CAA because it can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases such as asthma.[111] Additionally, there are potentially large financial impacts that accompany ozone nonattainment status: ADEQ estimates annual expenditures on ozone mitigation activities due to nonattainment status for the Phoenix metropolitan area alone of $89 million to $296 million.[112]

Reducing ozone emissions is a critical element of the TE plan given the manner in which this pollutant is formed. Ground-level ozone is not emitted directly into the air by human activities but is instead created by a chemical reaction between nitrogen oxides (NO_X), volatile organic compounds (VOCs) and sunlight.[113] Of the NO_X emissions in Maricopa County, 83% are the direct result of internal combustion engines.[114] Point sources such as power plants and industrial operations account for only 5% of NO_X emissions in the nonattainment area. To reduce ground-level ozone pollution, it is essential to reduce NO_X and VOC emissions. Accordingly, as internal combustion-powered engines are the largest contributor to NO_X emissions,[115] TE offers an important pathway to improving air quality, minimizing adverse health effects and reducing NAAQS nonattainment costs.

VOLKSWAGEN SETTLEMENT: ENVIRONMENTAL MITIGATION FUNDS

Arizona will receive approximately $57 million from the Volkswagen Diesel Settlement over the next ten years. The state's Beneficiary Mitigation Plan proposes to use this funding for projects that reduce NO_X emissions in areas of the state significantly affected by diesel emissions: 67% of the funds is proposed for school bus replacement, 24% for on-road freight replacement projects, and 9% for administrative costs.[116] As of November 19, 2019, 185 school buses and 37 on-road fleet vehicles have been scrapped, with funds for reimbursement distributed or in the process of being distributed to school districts and state agencies, respectively.[117] While electric vehicles – especially electric buses – are an option under this funding, the majority of these older diesel replacements have been with newer diesel vehicles. Additional EV charging infrastructure or other utility support could help to make school bus electrification a viable option in

[111] Environmental Protection Agency, "Ground-Level Ozone Pollution." Available at: https://www.epa.gov/ground-level-ozone-pollution.
[112] Arizona Department of Environmental Quality, "RE: Possible Modifications to ACC's Energy Rules," May 20, 2019.
[113] Environmental Protection Agency, "Ground-Level Ozone Pollution Basics." Available at: https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics#effects.
[114] Maricopa County Air Quality Department, "2017 Periodic Emissions Inventory for Ozone Precursors," November 2019. Available at: https://www.maricopa.gov/DocumentCenter/View/52917/2017-Periodic-Emission-Inventory-Ozone-PDF.
[115] Arizona Department of Environmental Quality, "Electric Vehicle Project." Available at: https://azdeq.gov/electric-vehicle-project.
[116] Arizona Department of Administration, "Beneficiary Mitigation Plan for the State of Arizona," June 8, 2018. Available at: https://vwsettlement.az.gov/sites/default/files/media/VWBeneficiary-Mitigation-Plan.pdf.
[117] VW Settlement Clearinghouse, "Settlement-Related Progress and State Contacts," November 19, 2019. Available at: https://vwclearinghouse.org/public/Settlement_Related_Progress_and_State_Contacts.pdf.

Arizona, although as discussed in Chapter 2 the state's hot climate has thus far proven challenging for e-bus technology at its current level of development.

VOLKSWAGEN SETTLEMENT: ELECTRIFY AMERICA

As part of its diesel emissions settlement, Volkswagen has also capitalized the $2 billion Electrify America initiative to expand zero-emission vehicle infrastructure and awareness over the 10-year period ending 2027. $800 million will be spent in California. The remaining $1.2 billion will be used to develop a long-distance highway charger network, support community-based local charging networks, and implement a nationwide, brand-neutral public EV education campaign. This $1.2 billion will be disbursed in four 30-month investment cycles of $300 million each. Table 4 below lists the funding allocations to different categories for Cycle 1 and Cycle 2 of the initiative.

Table 4: Electrify America Investments, Cycles 1 and 2

Investment Category	Cycle 1 ($ million)	Cycle 2 ($ million)
Highway Charging Infrastructure	$190	$65 - $85
Community Charging Networks	$60	$145 - $165
Autonomous Vehicle Infrastructure		$2 - $4
Public EV Education and Admin Costs	$50	$25
Branded Marketing		$10
Business Operation & Organization		$30
Total	**$300**	**$300**

Electrify America's national network will run through Arizona, and several stations have already been constructed. In its Cycle 2 investment plan the company estimates that three to six new DCFC stations will be installed in the Phoenix metro area. On average, stations installed as part of Cycle 2 will consist of five 150 kW chargers per site. Additionally, the national education campaign should provide general EV awareness support to the state. Figure 11 details the geographic distribution of Cycle 1 and Cycle 2 DCFC infrastructure investments.

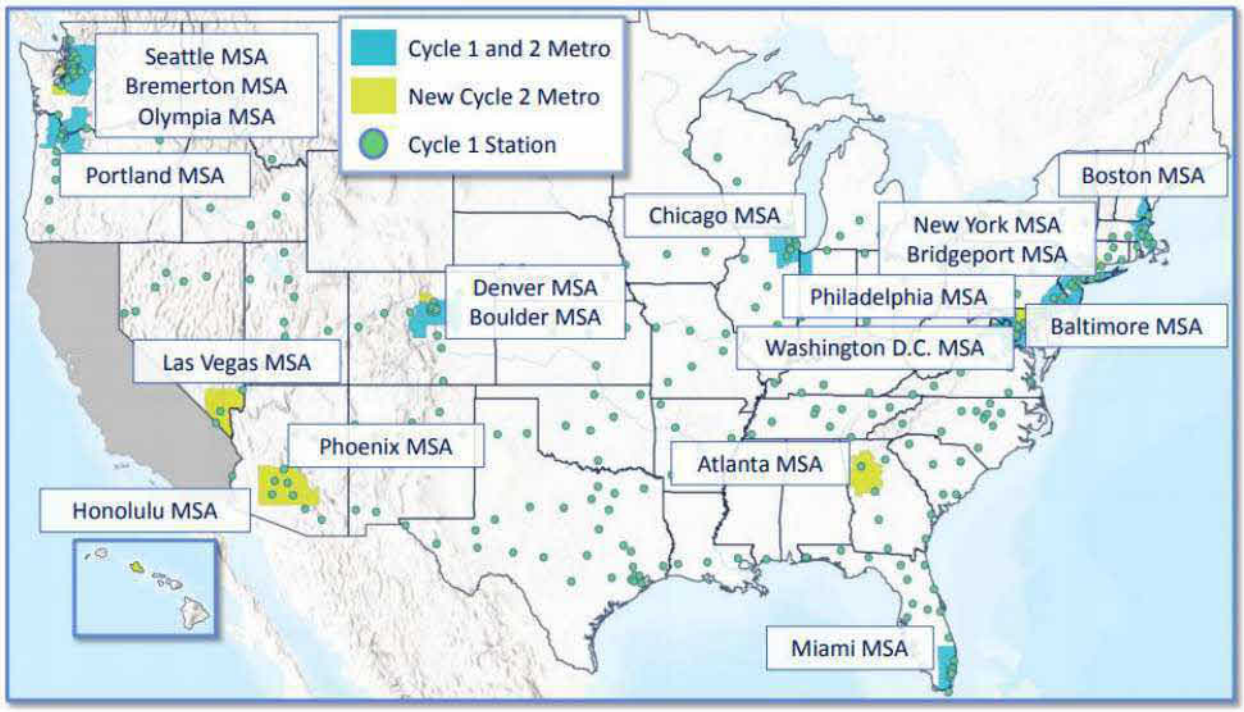

Figure 11. Electrify America's planned national DCFC charging network, plus metropolitan areas targeted for local charging infrastructure support[118]

FEDERAL HIGHWAY ADMINISTRATION ALTERNATIVE FUEL CORRIDORS

As of 2017, the U.S. Department of Transportation Federal Highway Administration has designated Interstate 10 between Phoenix and Tucson as a "signage ready" alternative fuel corridor for EVs. These corridors will have clear signs that indicate where EV chargers are located. The designation is also meant to encourage further EV infrastructure development along the routes. Other segments of I-10, as well as a portion of I-17, are considered "signage pending," indicating that sufficient alternative fueling infrastructure to merit signage has yet to be installed.

ADDITIONAL FEDERAL FUNDING

Several additional federal programs provide funding for TE technology:

- The Voluntary Airport Low Emissions (VALE) program incentivizes the purchase of alternative fuel vehicles at airports by funding the incremental cost of these models over conventional options; support infrastructure is also eligible for funding.[119]

[118] Electrify America, "National ZEV Investment Plan: Cycle 2," February 4, 2019. Available at: https://www.epa.gov/sites/production/files/2019-02/documents/cycle2-nationalzevinvestmentplan.pdf.
[119] Federal Aviation Administration, "Voluntary Airport Low Emissions Program." Available at: https://www.faa.gov/airports/environmental/vale/media/VALE-brochure-2017.pdf.

- The Airport ZEV Infrastructure Pilot program provides funding for up to 50% of the total costs of zero-emissions vehicles and associated infrastructure at airports.[120]
- The Low or No Emissions Competitive Program administered by the Federal Transit Administration provides funding to state and local governments to assist with the purchase or lease of zero-emissions and low-emission transit buses and supporting infrastructure.
- The Clean Diesel Program administered by the U.S. Environmental Protection Agency provides rebates and grants to replace diesel buses, trucks and nonroad vehicles or equipment with low-emitting alternatives. The grant funding under this program has been used by some jurisdictions to replace diesel vehicles with electric alternatives. In November 2018, the EPA awarded $414,000 to the Maricopa County Air Quality Department to retrofit and replace older, polluting diesel vehicles and equipment, including both school buses and heavy-duty trucks.[121,122] While these replacement vehicles are not scheduled to be electric, this program may nonetheless be a useful target for EV funding in the future.

Regional Transportation Electrification Initiative

Arizona is a founding member of a multi-state effort to promote TE in the western U.S. In October 2017 Governor Ducey signed the Regional Electric Vehicle (REV) memorandum of understanding (MOU) with seven other Western states to create an Intermountain West Electric Vehicle Corridor, laying the groundwork for coordinating state actions on electric vehicles across the region and supporting "the successful implementation of a robust EV charging station network."[123] This initiative aims to "make it possible to seamlessly drive an EV across the western states' major transportation corridors," and is enabling this goal through activities such as coordinating the signatory states on EV charging station locations and identifying opportunities to incorporate charging station infrastructure into planning and development processes.[124]

While the REV MOU is a recognition of the value in coordinating the actions of the signatory states, it does not commit the states to any specific timing or implementation goals and does not yet appear to have resulted in significant action toward the build-out of the charging corridor. It may serve as a useful framework through which Arizona's public agencies and utilities can further collaborate on how best to build out the infrastructure required to support TE along key interstates, but will require active engagement from these entities given the voluntary nature of the MOU.

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[120] Federal Aviation Administration, "Airport Zero Emissions Vehicle and Infrastructure Pilot Program." Available at: https://www.faa.gov/airports/environmental/zero_emissions_vehicles/.
[121] U.S. Environmental Protection Agency, "EPA awards Diesel Emissions Reduction Act grant for clean air projects in Arizona," November 20, 2018. Available at: https://www.epa.gov/cleandiesel/state-allocations.
[122] Maricopa County, "Arizona State Clean Diesel Program." Available at: https://www.maricopa.gov/4509/Clean-Diesel-Program.
[123] Arizona Office of the Governor, "Arizona Joins Agreement to Promote Electric Vehicle Corridor," October 12, 2017. Available at: https://azgovernor.gov/sites/default/files/rev_west_plan_mou_10_3_17_final.pdf.
[124] National Association of State Energy Officials, "REV West: Electric vehicle Policy Baseline for the Intermountain States," October 2018. Available at: https://www.naseo.org/data/sites/1/documents/publications/REVWest_Baseline_Final_Combined.pdf.

Arizona State Policies Supporting Transportation Electrification

Arizona has enacted a number of policies that aim to support transportation electrification in the state, as well as the increased use of alternative fuel vehicles (AFVs)[125] more broadly:

- ARS 28-876: Authorizing fines for parking conventional vehicles in spaces reserved for EVs.
- ARS 28-877: Permitting individuals driving AFVs and using alternative fuels to park without penalty in parking areas designated for carpool operators.
- ARS 28-2416, 23-2416.01 and 28-2511: Granting registered AFVs unrestricted access to high-occupancy vehicle (HOV) lanes, regardless of time of day or number of passengers. Requires registered AFVs to display an AFV license plate; plug-in hybrid electric vehicles receive a distinct license plate granting the same HOV access, although the PHEV-specific program has reached its 10,000-vehicle limit.
- ARS 49-573: Requiring federal fleets based in Arizona which operate primarily in counties with a population greater than 1.2 million people be composed of at least 90% AFVs. Relative to this regulation, alternative fuels include qualified diesel fuel substitutes and E85 in addition to the AFV-eligible fuels noted above.
- ARS 28-4414: Requiring new motor vehicle dealers to make information on AFVs and Arizona-based incentives available to consumers.
- ARS 41-803: Establishing AFV purchasing requirements for Arizona state agencies, boards and commissions. Relative to this regulation, alternative fuels include qualified diesel fuel substitutes and E85 in addition to the AFV-eligible fuels noted above. Requires the appointment of a state motor vehicle fleet alternative fuel and clean burning fuel coordinator, who shall develop, implement, document and monitor a statewide alternative fuels plan.
- ARS 9-500.04, 49-474.01, 49-541 and 49-571: Establishing requirements for local governments to encourage and increase the use of alternative fuels in municipal fleets. Requirements vary based on size and location of municipality.
- ARS 49-542: Exempting all-electric vehicles registered for the first time in Arizona from emissions testing.
- ARS 49-572: Requiring Arizona state agencies and political subdivisions operating alternative fueling stations to allow vehicles owned or operated by other state agencies of political subdivisions to fuel at that station, to the extent practical.
- Tax Credit for At-Home Electric Vehicle Charging Outlets: Granting Arizona taxpayers a $75 tax credit for installing an electric vehicle charging outlet (i.e., a 240V outlet capable of hosting a Level 2 charger) at their home.
- ARS 28-5801: Providing reduction in annual vehicle license taxes for AFVs.

[125] AFVs are defined in most Arizona Revised Statutes as vehicles fueled by propane, natural gas, electricity, hydrogen, or a blend of hydrogen with propane or natural gas.

These supportive policies serve as an important starting point for larger-scale TE, but on their own are unlikely to catalyze significant uptake of EVs. Many of the policies are focused on government fleets specifically, and also cover a broader category of AFVs rather than solely EVs. Given the charging infrastructure needed and the higher upfront costs of plug-in electric vehicles relative to some other AFVs, these policies are unlikely to spur significant adoption of *electric* vehicles within government fleets. These policies also do not directly address key barriers to EV adoption in the private sector, namely model availability, lack of information/education, upfront vehicle cost, availability of charging infrastructure, and lack of dealer incentives to sell EVs (see Chapter 2 for further discussion of these barriers).

AUTONOMOUS VEHICLE POLICIES

A discussed in Chapter 2, the development of autonomous vehicles (AVs) is closely linked to the growth of the EV market. Arizona is a national leader in enabling AV technology due its supportive regulatory environment. As a result, leading AV companies — including both traditional auto manufacturers and newer technology firms — have established a significant presence in Arizona and base much of their on-road research in the state.

The development of Arizona's AV-friendly regulatory environment has been driven largely by Governor Ducey through several executive orders:

- Executive Order 2018-09 (October 2018): Establishing the Institute for Automated Mobility, a collaboration between state agencies, universities and private firms to conduct research on AV technology, safety and policy. Intel is the founding private sector partner.
- Executive Order 2018-04 (March 2018): Updating Governor Ducey's original 2015 executive order (2015-09) with additional requirements for AV licensing and registration and defining key terms for use in laws and regulations pertaining to AVs.
- Executive Order 2015-09 (August 2015): Requiring various public agencies to support the testing and operation of self-driving vehicles on public roads in Arizona and enabling pilot programs on university campuses.

The focus on AV development in Arizona will likely increase the demand for EV infrastructure. Many transportation experts believe that electric AVs offer a variety of operational advantages over automating internal combustion vehicles, and therefore that the development of automated transportation will be intimately connected to EV technology. For example, the dramatically fewer components involved in EV motors compared with combustion engines allow for easier automation and control. The maturation of the AV market in Arizona will therefore further catalyze the EV market and the demand for EV-supportive policies, incentives and infrastructure.

Local Programs, Initiatives and Commitments

Cities and counties in Arizona have made different commitments to reducing emissions in the coming years. As transportation is the leading sector contributing to GHG emissions in these cities and counties, transportation electrification provides a method of achieving these long-term emission reduction goals.

At the local level a variety of TE initiatives exist, although most remain in a nascent phase.

- The Phoenix City Council unanimously adopted a goal of reducing GHG emissions 80% below 2012 levels by 2050 and 30% below 2012 levels by 2025. The city has also committed to carbon neutrality by 2060.[126]
- The City of Tucson recently announced its commitment to creating a "2030 District" by adopting sustainable building goals inclusive of water conservation and energy and transportation-related emissions reductions.[127] The City has also formed a Sustainability Working Group which will work with relevant stakeholders and City staff to develop the framework for a Climate Action Plan.[128]
- The City of Flagstaff set a goal of reducing greenhouse gas emissions 80% below 2016 levels by 2050, with interim targets of 15% emissions reduction by 2025 and 30% reduction by 2030.[129] The city's Climate Action and Adaptation Plan discusses the importance of encouraging EVs by providing a sufficient number of charging ports within the city, along with promoting alternative modes of transportation such as walking, biking, and public transportation. Flagstaff also recently adopted requirements for EV pre-wiring in new construction.[130]
- The City of Tempe has joined the Global Covenant of Mayors for Climate and Energy, and is currently working through a stakeholder process for the city council to approve its Climate Action Plan.[131] The plan lists methods of reducing GHG emissions from the transportation sector such as providing solar EV charging stations and encouraging community members to use public transportation.
- Both the cities of Phoenix and Tucson are recognized as members of the Clean Cities Coalition Network, where they work with vehicle fleets, fuel providers, and community leaders to promote the use of EVs and domestic fuels in order to reduce emissions from the transportation sector.[132]
- Pima County aims to reduce carbon emissions in line with the 2015 Paris Climate Agreement,[133] as the local governments within the county have set varying intermittent targets. As part of this effort the County will replace 120 conventional passenger sedans with EVs by FY 2023.

While reducing transportation-related emissions will no doubt be a key component of reaching these goals, these jurisdictions are just beginning to plan for TE. The City of Phoenix's "Transportation 2050"

[126] AZ Big Media, "Phoenix sets goal to reduce greenhouse gas emissions by 30%," January 10, 2018. Available at: https://azbigmedia.com/phoenix-sets-goal-reduce-greenhouse-gas-emissions-30/.
[127] The Daily Wildcat, "Seeing green: Tucson looks towards a sustainable future after becoming a 2030 district," February 7, 2019. Available at: https://www.wildcat.arizona.edu/article/2019/02/n-tucson-2030.
[128] City of Tucson, "Sustainability Report and Recommendations from the Commission on Climate, Energy, and Sustainability," September 17, 2019. Available at: https://www.tucsonaz.gov/sirepub/mtgviewer.aspx?meetid=1908&doctype=SUMMARY.
[129] City of Flagstaff, "Climate Action & Adaptation Plan," November 2018. Available at: https://www.flagstaff.az.gov/ClimatePlan.
[130] City of Flagstaff, "Building Safety," June 18, 2019. Available at: https://www.flagstaff.az.gov/494/Building-Safety.
[131] City of Tempe, "Climate Action Plan" November 2019. Available at: https://www.tempe.gov/home/showdocument?id=76425
[132] Clean Cities Coalition Network, "Valley of the Sun Clean Cities Coalition (Phoenix)," Available at: https://cleancities.energy.gov/coalitions/phoenix.
[133] Pima County, "Sustainable Action Plan for County Operations 2018-2025," October 2018.

plan does not feature electrification.[134] Pima County plans to replace up to 120 county vehicles with EVs, but further components of its transportation decarbonization plan have not been articulated. The City of Flagstaff's "Blueprint 2040 Regional Transportation Plan," published in March 2017, lists a number of future initiatives on vehicle electrification, but the city cited challenges to implementation posed by resource constraints and has made statements indicating it is likely to take a less proactive approach to TE in the near term.[135] Sun Tran, the public transportation service offered in Tucson, is collaborating with TEP on its first electric bus pilot program.[136]

[134] City of Phoenix, "Plan Elements." Available at: https://www.phoenix.gov/T2050/Elements.
[135] Arizona Daily Sun, "City council passes climate change adaptation plan, but will it be implemented?" November 24, 2018. Available at: https://azdailysun.com/news/city-council-passes-climate-change-adaptation-plan-but-will-it/article_e02d5890-7299-5aa6-8635-0ddec22d4979.html.
[136] Sun Tran, "Sun Tran Unveils City of Tucson's First Electric Bus," September 13, 2019. Available at: https://www.suntran.com/PDF/news/19_Sep_13_ElectrisBus.pdf.

4) Stakeholder Perspectives

Many stakeholders have participated in discussions of TE in Arizona, largely through the current proceeding at the ACC and the two related EV Stakeholder Meetings but also in other venues such as the recent Arizona Transportation Electrification Forum hosted by the Arizona State University Energy Policy Innovation Council, Plug in America and the Southwest Energy Efficiency Project. This chapter summarizes the primary topics of interest to the stakeholders and the perspectives across different groups.

Air Quality

A number of stakeholders have raised air quality and related health benefits as one of the key opportunities afforded by TE, including consumer advocates, EVSPs, environmental organizations, and ADEQ. ADEQ filed comments in the proceeding detailing the health impacts and regulatory costs of ozone pollution and discussing the potential benefits provided by TE.[137]

In its May 20, 2019 submission to the Commission, ADEQ noted that:

> *The Phoenix area, including parts of Gila and Pinal Counties, is currently a nonattainment area for the 2015 national ambient air quality standards (NAAQS) for ozone of 70 parts per billion (ppb). Based on 2018 monitoring data, Phoenix ozone concentration has been steadily increasing since 2016*[138]

ADEQ notes that EVs along with other transit solutions (e.g., carpooling, telecommuting and increased use of mass transit) will be essential to reducing emissions and attaining the 2015 ozone standard for the Phoenix area, where fossil fuel-powered vehicles are the largest single contributor to ozone pollution.[139] The recent MJ Bradley study filed in this proceeding by the SWEEP WRA estimates annual NOx reductions by 2030 and 2050 ranging from several hundred to several thousand metric tons, with a societal value of up to nearly $100 million per year under a high EV, high renewable electricity scenario.[140]

Utility Ownership and Competition

The Commission Implementation Plan allows for utility investment in and cost recovery of various EV infrastructure investments. A diverse group of stakeholders are supportive of utility ownership of some portion of the infrastructure enabling TE, including environmental organizations, technology providers, EVSPs, and consumer advocates. These stakeholders recognize that playing this role leverages the utilities' core competency in installing electrical equipment, and that some charging locations are unlikely to be

[137] Arizona Department of Environmental Quality, "RE: Possible Modifications to ACC's Energy Rules," May 20, 2019.
[138] Ibid.
[139] Ibid.
[140] MJ Bradley & Associates, "Electric Vehicle Cost-Benefit Analysis," December 2018.

addressed by the private market. Several stakeholders also note that utility ownership of charging infrastructure can enable managed charging that is better coordinated with the rest of the electric system. A number of stakeholders including EVSPs such as Tesla and EVgo are supportive of "future proofing" make-ready investments to accommodate larger charging capacities in the future as technology develops.

Two parties – ChargePoint and SWEEP – note the importance of site hosts being able to make their own selection of EVSE provider and number of ports. These parties remain supportive of utility ownership of make-ready infrastructure but stress the importance of maintaining competition in the provisioning of charging stations themselves.

Several parties oppose utility ownership of infrastructure given concerns that it could increase costs for non-EV customers, or for other reasons. For example, the Western States Petroleum Association believes intervention is not necessary given a market failure hasn't convincingly been shown to exist, while several other parties voiced skepticism of the need for utility involvement to catalyze the EV market. Overall, however, most parties recognize that there is a distinct role for the utilities to play and voiced strong support for their investment in TE.

Benefits, Costs and Potential Cross Subsidies

There is broad agreement among stakeholders that longer-term investments in TE should be driven by some form of cost-benefit analysis. While some parties have suggested that such an analysis be performed before launching the proposed pilot programs, most support assessing these initiatives once they are operational to understand the realized costs and benefits, which can then help to inform future programs and investments.

As noted above, one concern from several stakeholders involved in the TE discussions is that of cost shifting or cross subsidies between EV customers and non-EV customers due to the inclusion of utility TE investments in the rate base. AARP (formerly the American Association of Retired Persons) raised this concern several times and has also advocated for EV pilot program costs to be segmented from the costs of basic electric service. The Grand Canyon State Electric Cooperative Association and Arizonans for Electric Choice and Competition also note concerns over the risk of cross subsidization. A study filed by the Arizona Free Enterprise Club assessed electric vehicle subsidies in Arizona, concluding that public incentives for EVs overcompensate for the benefits provided.[141] However, this analysis focuses narrowly on the value of avoided carbon dioxide emissions, and fails to consider many of the benefits recognized by the majority of stakeholders, such as air quality improvements and reduced average cost of electricity service due to improved grid asset utilization, and also uses an unrealistically short five-year study period.

Numerous other stakeholders reference the beneficial effect that EV charging can have on retail rates for all electric customers, if charging is managed properly to avoid increasing system costs. Stakeholders repeatedly cited the SWEEP / MJ Bradley study because of its direct focus on the costs and benefits of the

[141] Arizona Free Enterprise Club, "It Ain't Easy Being Green: A Cost-Benefit Analysis of Electric Vehicles in Arizona," June 4, 2019.

increased penetration of PEVs in Arizona. The study found consistent net benefits across four different scenarios (two EV penetration cases and two charging assumptions) across all electric utility customers.[142]

Rate Design

Stakeholder input on rate design for EVs is mixed. While most parties agree that managed charging of EVs is critical to attaining the benefits of increased utilization of electricity system assets, they differ as to how they believe this can or should best be achieved.

Providers of public charging stations such as ChargePoint, EVgo, Tesla and Electrify America advocate for removal of, or relief from, demand charges, which are based on customers' highest level of energy use during applicable periods of each billing cycle. They say these charges, which are included in many pricing plans for larger commercial customers, are a significant impediment to EV growth given the large and concentrated power needs of charging stations. This view is echoed by SWEEP and several other parties who do not support demand-based rates for EV charging. Proposed alternatives include TOU rates with significant price differentials, providing demand charge credits (i.e., maintaining the rate structure but providing relief from the demand charges), and setting rates based more closely on actual marginal costs to the utility. Tesla notes that new EV rates should be available to both new and existing charging station locations.

Other stakeholders contend that demand charges are critical to both recovering system costs and ensuring that incentives exist to shift charging out of peak periods. Still other parties have stressed the importance of maintaining rate structures free of price distortions, arguing that any incentives provided for EVs should be separate from the underlying electricity rates to ensure economic efficiency and also transparency in the value and uptake of incentives.

Consideration of Underserved Communities and Areas

There is general agreement among stakeholders serving limited-income residents that customers in disadvantaged communities should be exempted from paying for EV programs, given that – at least in the near-term – these customers are less likely to benefit directly from such programs. Both the Residential Utility Consumer Office (RUCO) and consumer advocate Wildfire (formerly the Arizona Community Action Association) have stressed that the utilities' EV pilot proposals should include detail as to both how disadvantaged community customers will be engaged and how these customers will be exempted from paying for EV programs over the first several years.

Several parties have also noted that specific consideration will need to be given to customers living in multi-unit dwellings and to customers in more rural parts of the state, as programs designed for residential customers in single-family homes or for denser urban environments are unlikely to provide the same benefits to these customers.

[142] MJ Bradley & Associates, "Electric Vehicle Cost-Benefit Analysis," December 2018.

5) Existing and Planned Utility Programs and Incentives

APS, TEP and UNS Electric are ramping up their TE programs, beginning to address some of the key impediments to the increased adoption of EVs in Arizona. This chapter describes the various initiatives these utilities are currently undertaking and how these programs are supporting EV growth in their service territories.

Arizona Public Service

APS estimates that the number of light-duty EVs in its service territory will grow significantly in the coming years, from about 10,000 vehicles in 2018 to between 200,000 and 650,000 by 2038. APS is working to support this EV adoption in the Valley of the Sun through a combination of pilot programs, research initiatives and customer outreach, and anticipates increasing TE initiatives as the market develops further.

TAKE CHARGE AZ

Take Charge AZ is APS's flagship EV pilot program, through which the utility is installing and owning Level 2 EVSE (charging stations) at a variety of locations including businesses, government agencies, nonprofits, and multifamily residences. APS is also deploying DCFC in strategic locations near highway corridors. APS launched the Take Charge AZ program in May 2019 and anticipates deploying over 200 plugs through 2021. This estimate is informed by recent research on EV growth and the required charging capacity required to meet this need in a cost-effective manner (described in further detail below).

> **L2 Program**: As of September 30, 2019, APS received 81 valid applications from customers interested in L2 EVSE,[143] of which 74 had entered the design phase. The majority of these applications are for EVSE at sites that will provide workplace charging. APS is currently partnering with two different providers of EVSE – ClipperCreek and ChargePoint (selected through a competitive bidding process) – which allows customers to choose the equipment option which best suits their needs.
>
> **DCFC Program**: The DCFC portion of the Take Charge AZ program is progressing as well: APS selected a vendor to partner with (through a competitive bid process) and is currently completing contracts to formalize this relationship. APS is beginning to identify target locations for DCFC installations and is establishing a siting process. In order to "future proof" these installations APS will design charging sites to accommodate the higher capacity batteries anticipated in future EV models and install multiple charging units to accommodate multiple EVs at one time.

[143] Applications from customers at sites that already have EVSE do not qualify, given the program focus on creating a broader EV charging network.

In addition to directly supporting EV adoption through these EVSE installations, APS will gain valuable insights and expertise in the EV charging space by collecting data from the pilot installations; APS plans to collect data from the pilot charging locations for five years. The program is already providing valuable insights, for example:

- Some prospective workplace charging site hosts would like their charging units to be available to the public rather than only to employees;
- Some prospective site hosts have emphasized a desire for networked chargers that will allow them to accept payment from end-users (rather than providing charging as an amenity);
- Upgrade and construction costs vary widely across sites based on existing infrastructure.

EV RATES

APS is currently evaluating rate tariff designs to support the unique electricity usage of DCFC stations. These rates would be intended for potentially APS-operated as well as third party-operated charging sites. At the residential level the existing Saver Choice Max rate is the ideal rate for EV drivers, with the lowest off-peak rate to encourage overnight charging.

EDUCATION AND OUTREACH

APS participates in EV events throughout the state, providing customers with information on the Take Charge AZ Program as well as general information on EVs. Planning for additional events is in progress.

INDUSTRY INITIATIVES

APS is a founding member and co-director of Electric Vehicles Arizona (EVAZ), a member of the Electric Drive Transportation Association, part of the Smart Electric Power Alliance's EV Working Group, and is on the board of the Valley of the Sun Clean Cities Coalition. APS also participates in the Electric Power Research Institute (EPRI) electric transportation program and the National Electric Transportation Infrastructure Working council, which brings together experts from the utility and automotive industries to share knowledge, develop standards, and learn about the latest in EV technology.

RESEARCH INITIATIVES

In addition to the pilot program and planned EV rates detailed above, APS has been conducting several in-depth research initiatives to develop a comprehensive understanding of both the opportunities and the impacts to be expected from TE in its territory. This research has been undertaken in collaboration with Navigant Consulting, and has focused on three key questions:

- What level of EV adoption should APS anticipate in its service territory?
- What charging network will be needed to support this adoption?
- Where in this network should DCFC installations be located to address gaps and create a robust EV charging system?

EV Adoption Forecast: APS and Navigant estimate that the number of light-duty EVs in its service territory will increase from around 10,000 vehicles in 2018 to between 200,000 and 650,000 by 2038, as shown in Figure 12. This upper bound estimate equates to approximately 1.5 million EVs statewide in 2038 and assumes consumer awareness and preferences for EVs will increase significantly in the near-term. The base case scenario of approximately 250,000 LD EVs in APS's service territory by 2038 represents a 25-fold increase in EVs relative to 2018, indicating that even in the absence of more aggressive market transformation, significant growth in this market will occur over the next two decades.

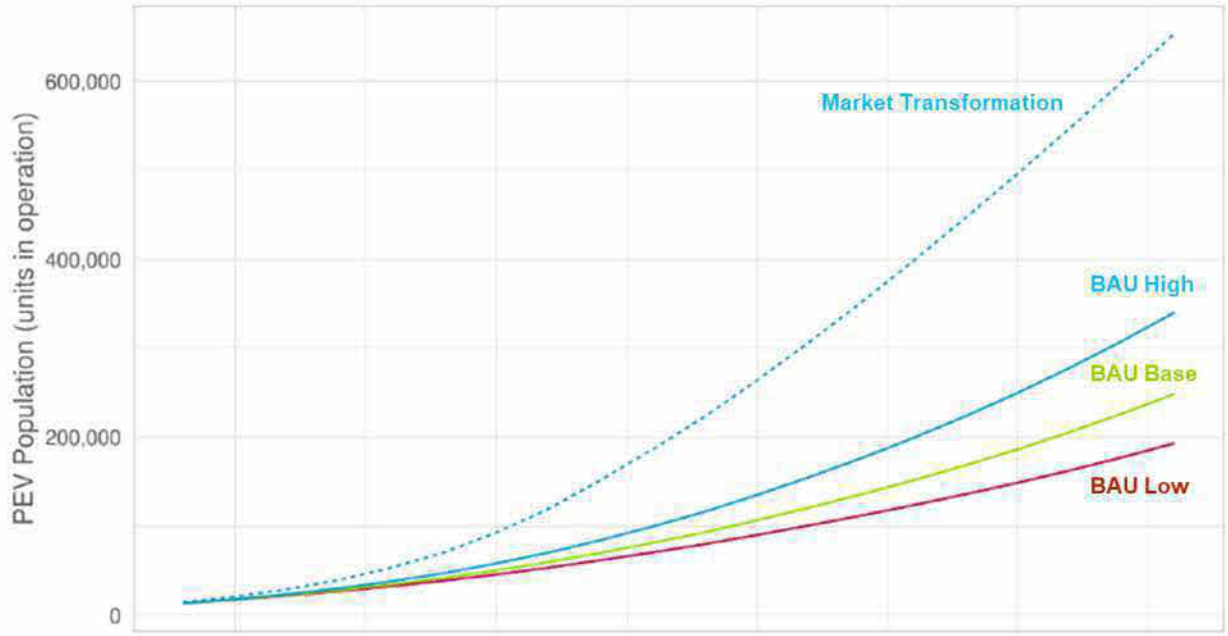

Figure 12: EV Adoption in APS Territory[144]

Charging Analysis: APS and Navigant have also conducted a charging station siting analysis to identify optimal EVSE locations that meet the need forecast through EV adoption modeling. Different EV adoption scenarios and objective functions (e.g., minimizing the number of charging facilities or maximizing the covered range) provide a spectrum of potential charging network outcomes and configurations.

DCFC Screening: As part of the charging analysis, APS and Navigant evaluated the existing DCFC charging network and modeled growth in DCFC charging needs over the study period under different scenarios. The analysis showed that there are currently 157 DCFC ports at 29 locations in APS service territory. To serve the 2038 PEV vehicle forecast in the Base Scenario, 650 public DCFC ports would be needed. To support the 2038 PEV vehicle forecasts in the Market Transformation Scenario (which estimates 650,000 PEVs in APS territory by 2038), 1,700 total public DCFC ports would be needed. In addition to providing a perspective on anticipated charging needs, this evaluation identified the highest-priority DCFC sites required to address gaps in coverage in order to provide a complete DCFC corridor charging network

[144] Navigant Consulting, "Electric Vehicle Adoption Forecast and Charging Station Siting Analysis: Arizona Public Service," October 2, 2019.

within APS territory. APS will incorporate the identified high-priority sites into the DCFC portion of the Take Charge AZ program.

NISSAN LEAF REBATE

In partnership with Nissan APS offered a $3,500 rebate for the purchase of the LEAF EV until December 31, 2019. This rebate, funded wholly by Nissan North America, was offered through participating local Nissan dealers, and helped to spur the purchase of Nissan LEAFs by APS customers. The program will be extended through March 2020.

DEMAND SIDE MANAGEMENT PLANS

In addition to the EV initiatives described above, APS included a variety of TE proposals in its 2018 and 2019 Demand Side Management (DSM) Plans filed with the ACC. While these plans have not been approved, they nonetheless represent TE efforts APS has considered and is enthusiastic about implementing.

Managed EV Charging Pilot Program: APS initially proposed this pilot in its 2018 DSM Implementation Plan. The program would focus on managing the load shape of EV charging through scheduling and demand response control. APS proposed to cover the cost of the pilot program, education and outreach, and program support through the 2019 DSM Plan, rather than the full implementation costs (including infrastructure and EVSE costs) proposed in the 2018 plan. In APS's 2020 DSM Implementation Plan, this program will be replaced with the Demand Management for Electric Vehicle Charging pilot program, which is designed to gather better data on EV charging use patterns, encourage beneficial off-peak EV charging behavior, and provide opportunities to connect EV charging stations for future demand response and EV load management programs.

EV Pre-Wire Program: In its 2019 plan, APS maintained the same proposed builder incentive for residential new construction as was put forth in the 2018 plan. The program would offer $100 per home constructed with pre-wiring to enable L2 EV charging.

Standby Truck Refrigeration and Electric Forklifts: In the 2019 DSM plan APS proposed adding standby truck refrigeration and electric forklifts as new electrification measures to be included as part of the Non-residential Large Existing Facilities and New Construction programs. Refrigerating trucks using electric power rather than idling diesel engines when at truck stops or distribution facilities improves local air quality while also reducing fuel costs. APS proposed offering incentives of up to $1,000 per docking bay for eligible, newly installed electric conversion units. Replacing diesel- or propane-powered forklifts with electric units similarly improves local air quality and reduces operating costs, including an additional benefit of decreasing the need for ventilation by removing internal combustion (and the related emissions) from indoor spaces. APS proposed an incentive of up to $500 per new electric forklift and up to $2,000 per conversion of existing internal combustion forklift to an electric version.

APS MARKETPLACE

APS is currently working with a vendor to develop an EV Marketplace, where customers can view a variety of EVs and make comparisons with other types of vehicles. This marketplace will help customers identify optimal charging stations and even purchase them from the website. Future capabilities will also include test drives and advisory services for installing home charging stations.

Tucson Electric Power

TEP is significantly ramping up its TE initiatives in recognition of the value that EVs can bring to its customers and to Arizona as a whole. The company is working to implement a number of TE programs that were approved by the in February 2019.[145] These initiatives include residential and non-residential EV programs, education and outreach activities, employee incentives, and investments in EV infrastructure. TEP's total budget for customer facing EV initiatives is approximately $2.16 million, channeled through its demand side management program. TEP anticipates an additional capital investment of up to $8 million for EV charging infrastructure through the Smart City EV BuildOut Plan.

RESEARCH INITIATIVES

TEP is conducting two EV studies with Navigant Consulting: an **EV Penetration and Baseline Study** and a **System Cost Benefit Analysis**. The penetration and baseline study will provide TEP with a more detailed depiction of EV usage in its service territory, helping to inform and better target programmatic offerings. This study is expected to be completed by February 2020. The cost benefit analysis will allow TEP to better understand the value that different types of EV provide to its system and will therefore also help to inform which TE initiatives present the best opportunities for its customers overall. TEP expects this analysis to be completed in December 2019.

RESIDENTIAL PROGRAMS AND INITIATIVES

TEP currently offers discounts on two different **residential TOU rates for EV customers**, the Time-of-Use and Demand Time-of-Use plans. Both pricing plans provide EV customers a 5% discount on a portion of their bills during off-peak periods,[146] aiming to incentivize charging during times of lower system demand.

TEP will soon launch two optional, EV-specific residential TOU rates that were approved by the ACC in July 2019[147] – the *Residential Super Off-Peak Time-of-Use Electric Vehicle* tariff and the *Residential Demand Super Off-Peak Time-of-Use Electric Vehicle* tariff – which are structured to incentivize EV charging during off-peak hours. The new rates incorporate a Super Off-Peak period (10 p.m. to 5 a.m. in both Summer and Winter) priced one cent lower than the non-EV Off-Peak period, and also include an Off-Peak "buffer" period between the On-Peak and Super Off-Peak periods; that buffer is intended to protect EV customers

[145] Arizona Corporation Commission, "Decision No. 77085," February 20, 2019.
[146] The 5% discount for EV customers during off-peak periods applies to the Base Power and Purchased Power and Fuel Adjustment Clause charges.
[147] Arizona Corporation Commission, "Decision No. 77290," July 19, 2019.

from inadvertently paying On-Peak prices when beginning to charge their EVs prior to the start of the Super Off-Peak period.

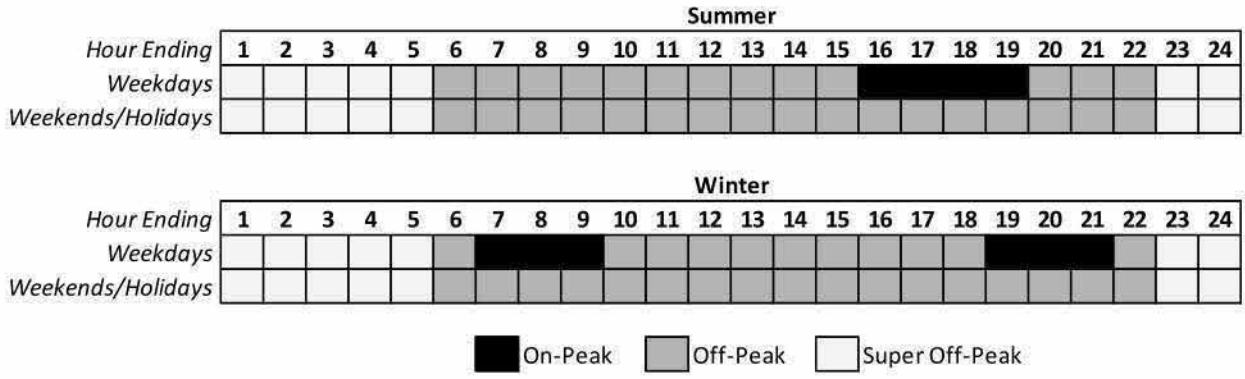

Figure 13: TEP Residential EV TOU Periods

The demand-based rate differs from the non-demand rate in that energy charges are based on a combination of volumetric and demand charges rather than solely on a (higher) volumetric charge. TEP is offering this rate as a savings opportunity for customers who are able to effectively manage their EV charging. The company estimates that customers charging their vehicles solely during the Super Off-Peak period could save about 50 percent relative to their costs on the non-demand EV rate. TEP estimates that charging during the Super Off-Peak period equates to a cost per gallon of gasoline equivalent of $0.92 and $0.46 for the non-demand and demand-based tariffs, respectively.[148]

Through its **Smart Homes EV Pilot Program** TEP offers owners of existing homes rebates covering up to 75 percent of the cost of installing EVSE. Customers installing a qualified two-way, communicating Level 2 EVSE unit can receive up to $500, while installations of one-way, non-communicating Level 2 EVSE units are eligible for up to $250. Rebate recipients are required to enroll in and remain on a TEP TOU rate for at least two years. TEP is also promoting EV adoption among new home buyers by working with builders to make new construction "EV Ready" through pre-wiring for EVSE. Currently incentives of $100 per home are offered to builders.

TEP is currently working with Clean Power Research to develop a **Residential EV Calculator**. This calculator will help customers estimate the costs and benefits of switching to an EV, providing useful and personalized information that can help potential EV adopters to understand the financial opportunity. The initial version of the calculator, expected to be by January 2020, will provide calculations based on electricity usage data entered by customers. By the end of the first quarter of 2020 TEP plans to release an updated version of the calculator which will include customer-specific usage data directly from TEP, improving the user experience and providing more accurate results.

[148] This estimate assumes a fuel economy of 27.9 miles/gallon and a kWh/mile efficiency of 0.326.

COMMERCIAL EV PROGRAMS

Through its **Smart City EV BuildOut Plan** TEP anticipates investing up to $8 million in EVSE and related infrastructure in the Tucson area, aiming to provide a portion of the additional charging capacity necessary to support the growth of TE in the region. EVSE will be installed at workplaces, multifamily dwellings, colleges and universities, schools, retail locations, commercial fleet depots and along local highways. TEP has chosen to focus initially on Level 1 and Level 2 EVSE, rather than DCFC, given expectations of improved cost-effectiveness for these smaller-scale infrastructure investments.

TEP is implementing a **New Smart School EV & EE Program** to provide EVSE as well as energy efficiency measures and grants for energy efficiency education at schools within its service territory. Providing educational opportunities at schools will help staff, students and their families transition to EVs, and will also stimulate interest in TE among students and within the educational community more broadly.

TEP will also be investing in an **EV Charging Management Platform** to enable control and management of EVSE. This investment will allow TEP to more effectively balance loads and resources, and to gain experience in this area in anticipation of the growing EV loads in coming years. Additionally, this investment will help to unlock the benefits of the other EV programs being implemented by providing enhanced monitoring and management capabilities.

TEP is developing two different tools for use in assisting businesses in their EV decisions. The **Total Cost of Ownership Fleet Planning Tool** – a collaboration with consultant West Monroe Partners – will be used to help commercial customers understand the TCO for different potential EV fleets, providing a perspective on upfront costs, return on investment, and lifetime savings. While the tool will primarily be focused on estimates of customer costs, it also will allow for consideration of TEP infrastructure cost expectations. Separately, TEP is working with Navigant Consulting to develop an EV **Infrastructure Cost Estimation Tool** to be used for estimating both customer and TEP infrastructure costs. Both tools are expected to be available in December 2019.

CURRENT COMMERCIAL EV PROJECTS

City of Tucson Parking Garages: TEP is in the process of developing a project with Park Tucson, the city parking authority that serves residential and commercial customers as well as tenants of office buildings. Through an R&D agreement, TEP would cover a portion of the costs of EVSE and related infrastructure. TEP anticipates this project will provide 16 charging stations across four different parking garages.

Tucson Police Department: TEP is working to finalize a proposed partnership with the Tucson Police Department, which anticipates purchasing ten EVs within the next six months. Five of the EVs will serve the Park Safety Program and will be supported by charging stations in three police stations. An additional five EVs will be used by detectives at the main police station. Through this program, TEP would both serve as an advisor to the police department and would cover a portion of the costs of EVSE and related infrastructure through an R&D agreement.

Public Bus Project: Sun Tran, the public transit operator for the Tucson metropolitan areas, has leased an electric bus from manufacturer Gillig that is scheduled for delivery in January 2020. In collaboration with

TEP, installation of the necessary charging infrastructure has already been completed. Sun Tran anticipates purchasing four to five additional e-buses by January 2021, and TEP will continue to support the expansion of this fleet by assisting with installation of EVSE and related infrastructure.

Pima County Project: Pima County currently has a fleet of 29 EVs and is in the process of installing EVSE to support these vehicles. The County anticipates buying 40 additional EVs in 2020, and TEP will be providing incentives for the charging equipment and infrastructure upgrades to support these vehicles. Pima County expects to have a total of 151 electric sedans in their fleet by the end of fiscal year 2023. By the end of fiscal year 2025, the County expects its fleet also will include 154 electric light-duty trucks. TEP will continue to support the County in an advisory role and by assisting with installation of EVSE and related infrastructure.

COMMERCIAL EV IMPLEMENTATION PROJECT

TEP has recently concluded a request for proposal process for its **Commercial EV Implementation Project**, awarding the contract to CLEAResult. This contract was recently finalized, and the project will begin in December 2019. The multi-faceted program will tie together the various commercial EV initiatives and offerings that TEP is either planning for or currently implementing. The goal of this implementation project is to provide commercial customer education and outreach; promote initiatives which encourage EV saturation; motivate partnerships between public and private sector entities to promote EV ownership; and facilitate the integration of charging station infrastructure at private residences and public facilities. CLEAResult will be responsible for overseeing all customer-sited infrastructure and equipment; prioritizing and ranking projects for receipt of available incentives (ranking based on best overall costs and benefits); customer contracts; and reporting on program implementation progress. The initial phase of the project will focus heavily on promoting digital engagement with potential EV adopters and hosts of EVSE. TEP anticipates the program will be fully operational in March 2020.

REGIONAL ELECTRIC VEHICLE PROGRAM

TEP will conduct an R&D project to support Arizona's participation in the **Regional Electric Vehicle Plan for the West** established in October 2017 through a Memorandum of Understanding signed by Arizona Governor Doug Ducey and governors of other western states. TEP's efforts will support the "Rev West Plan" by providing EV fast charging infrastructure along freeways in the service territories of TEP and UNS Electric, in cooperation with other participants in the regional initiative.

INTERNAL EMPLOYEE ENGAGEMENT

TEP is planning to roll out its employee EV engagement program – **Walk the Talk** – in the first quarter of 2020. This initiative will provide incentives to employees for adopting EVs. Details are still under development.

STRATEGIC PLANNING

In addition to the comprehensive, statewide TE Plan detailed in this report, TEP is also working on an **EV Strategic Roadmap for Tucson** with assistance from Navigant Consulting. The roadmap will establish a

vision, mission and goals, and will include an implementation plan with prioritized initiatives to realize this vision in the next five years.

UNS Electric

In January 2018, UNS Electric filed an amendment to its Demand Side Management Implementation Plan proposing several TE initiatives. The plan, which has not yet been approved, is reflective of UNS Electric's proposed work to support EVs, which it hopes to commence as part of the implementation of this statewide TE plan.

6) Transportation Electrification Opportunities in Arizona

As described in Chapter 2, there is a growing opportunity to expand transportation electrification in Arizona across multiple vehicle types. The following tables provide a high-level estimate of the opportunities afforded by electrification of two different vehicle segments in Arizona, including annual fuel usage, equivalent GWh required, and annual emissions. Due to limited data availability, only LDVs and transit buses are shown here. A more detailed market-sizing analysis including further segmentation between different LDV types (e.g., personal, TNC, and fleet) will be conducted in Phase Two.

The following tables estimate the impacts of electrifying 100% of LDVs and transit buses in the state, providing an upper bound on the opportunity represented by each vehicle category. Given the large number of vehicles and the maturity of the technology, LDVs provide by far the largest near-term opportunity for reducing petroleum consumption and tailpipe pollution. However, other types of EVs also offer significant air quality benefits, especially given that conventional medium-duty and heavy-duty vehicles primarily run on diesel rather than gasoline.

Table 5: EV Opportunity, Fuel Use and Equivalent GWh

Vehicle Type	Status of EV Technology	Registered Vehicles[149]	Annual Fuel Use (Thousand Gallons)[150]	Annual GWh Equivalent[151]
LDV	Early Commercial	5,256,472	2,832,600 (gasoline)	20,000
Transit Buses	Pilot / Early Commercial	1,079	12,900 (diesel)	100

[149] ADOT, "Motor Vehicle Division Statistical Summary," 2019. https://azdot.gov/motor-vehicles/statistics/motor-vehicle-division-statistical-summary.
[150] US Department of Energy, "Alternative Fuels Data Center," December 2018. https://afdc.energy.gov/data/.
[151] EPRI, "Electric Vehicle Driving, Charging, and Load Shape Analysis," July 2018. http://mydocs.epri.com/docs/PublicMeetingMaterials/ee/000000003002013754.pdf.

Table 6: Annual Emissions Avoidance Potential from Electrification of LDVs and Transit Buses

	Annual Emissions (tons)[152,153,154]				
Vehicle Type	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**SO_X**	**NH_3**
LDV	2,100	540	16,100	160	1,100
Transit Buses	17	4	350	0.5	3

While these figures provide a high-level estimate, further analysis in Phase Two will provide a more detailed assessment of the fossil fuel and air pollution reduction opportunities afforded by TE. This further market-sizing analysis will include elements such as:

- Scale of TE opportunity by vehicle segment;
- Emissions impacts from each vehicle type at different levels of electrification;
- Assessment of costs and benefits for vehicle types presenting largest areas of opportunity.

[152] Maricopa County emissions data by vehicle type scaled to represent statewide emissions, using proportion of gasoline and diesel consumption in Maricopa County relative to Arizona total consumption.
[153] Maricopa County Air Quality Department, "2017 Periodic Emissions Inventory for PM10," November 2019. Available at: https://www.maricopa.gov/DocumentCenter/View/53617/2017-Periodic-Emission-Inventory-PM10-PDF.
[154] Arizona Department of Transportation, "Arizona Gasoline Gallons" and "Estimated Arizona Use Fuel Gallons Consumed," August 5, 2019. Available at: https://azdot.gov/sites/default/files/2019/05/Gasoline-Gallonage.pdf and https://azdot.gov/sites/default/files/2019/05/Diesel-Gallonage.pdf.

7) Overcoming Barriers to Adoption: Potential Programmatic Solutions

The preceding chapters have described the current transportation electrification landscape and the opportunities afforded by these technologies. This chapter identifies specific gaps that remain in achieving these opportunities in order to highlight strategic actions to be expanded or further explored. Phase Two will focus on defining the roles of the utilities and other stakeholders in addressing these gaps.

Gaps Analysis

The following table summarizes the potential utility actions which can address the primary TE barriers to the adoption of light-duty EVs and provides select examples of current utility initiatives focused on overcoming these barriers in Arizona (Chapter 5 describes the full complement of current utility initiatives). Some of these utility actions focus on overcoming multiple barriers. The "Addressable Gap" describes how the barrier persists beyond current initiatives and can help to inform the utilities' actions as they further develop their TE programs. Potential actions are described in further detail in the following section; commercial fleets are discussed separately.

It is important to note that not all of the gaps can be closed – in full or in part – by the utilities alone. Through more intensive engagement with state and local government and stakeholders in Phase Two the utilities expect to identify appropriate roles for these other actors, and to solicit their support accordingly.

Table 7: Transportation Electrification Gaps Analysis (Personal LDVs)

Market Barrier	Potential Utility Actions	Current Utility Initiatives (Select Examples)	Addressable Gap
Limited Awareness of EVs	Education & Marketing Electrify utility vehicles	APS participation in EV events TEP Residential EV Calculator	EVs remain outside of most consumers' consideration when purchasing a vehicle
EV Model Availability	None	None	EV models remain largely smaller and/or luxury vehicles (this gap is not directly addressable by utilities)

Upfront Cost Premium	Employee discount programs Engage automakers	TEP planned *Walk the Talk* employee program Nissan LEAF Discount	Upfront cost of EVs deters customers, even when TCO is lower
Lack of Charging Infrastructure & Related Range Anxiety	Deploy additional EVSE (public, workplace, multi-family) Advocate for EV-readiness in building codes	APS *Take Charge AZ* program APS *Charging Siting* analysis TEP *Smart Homes EV* and *Smart Cities EV* programs MAG EV pre-wiring guidance (from SRP)	Charging infrastructure to address range anxiety and spur EV adoption lags current installations
Rate Design	Design alternate tariffs for EV service providers	APS and TEP plans to introduce DCFC rates	Demand charges present a challenge for EVSPs at current low utilization rates
Lack of Dealership Incentives	Engage automakers	Nissan LEAF Discount	Conventional LDVs will remain default choice without additional dealer incentive to sell EVs
Grid Integration Challenge	**Potential Utility Actions**	**Current Utility Initiatives (Select Examples)**	**Addressable Gap**
Distribution Impacts and Upgrade Costs	Expand EV TOU rate options EVSP infrastructure buildout in low-cost locations Pilot programs to understand grid impacts	TEP EV TOU discount and planned EV-specific TOU rates APS TOU rates APS proposed *Demand Management for EV Charging* pilot program	The need to manage charging will become more acute as EV loads grow; without active planning upgrade costs will be high
Integration of Renewables	Support and enable expanded workplace charging	APS *Take Charge AZ* program TEP *Smart Cities EV* program	Most EV charging currently takes place at home and is poorly aligned with the timing of renewable generation

Potential Actions

ADDITIONAL EVSE DEPLOYMENT

Lack of sufficient public charging infrastructure – and the related range anxiety – is a significant impediment to further TE. While third-party EVSPs are installing new charging stations throughout Arizona, and the utilities are beginning to roll out additional EVSE through their pilot programs, there remains a significant gap between the scale of required infrastructure and the expected growth in EVs.

The utilities can help to address this gap both by providing EVSE directly, especially in areas that are less likely to be served by the private market, and also by working with EVSPs to provide make-ready infrastructure for third-party charging stations. It will be important to utilize open technical standards when developing charging infrastructure to ensure interoperability and enable a robust, interconnected network of stations, regardless of operator.

EDUCATION & MARKETING

The utilities are currently providing education and outreach to improve awareness of EVs. These initiatives can be scaled up to increase impacts as customers remain largely unaware of or poorly informed about the benefits of EVs. Additional activities include further participation in Ride-and-Drive events and creation of additional, educational materials that can help to improve awareness for specific groups, such as residential customers, taxi and TNC drivers, and commercial fleet managers.

EVSP INFRASTRUCTURE BUILDOUT IN LOW-COST LOCATIONS

To avoid or minimize distribution upgrade costs, the utilities can identify and develop potential charging sites with sufficient capacity to accommodate new EV loads. This can either be done as part of utility EVSE development, or as part of make-ready programs where the charging equipment will be provided by a third-party EVSP. The utilities can also provide resources to EVSPs to help these companies identify more and less expensive sites to develop.

PILOT PROGRAMS TO UNDERSTAND GRID IMPACTS

Pilot programs are critical to gaining a better understanding of the impacts that growing EV load will have on utility systems. The utilities' current pilot programs will provide EV charging across a variety of different locations (e.g., workplaces, multifamily dwellings, etc.) at both Level 2 and DCFC sites, as well as valuable data on customer charging patterns, utilization rates and distribution system impacts. Future programs will be informed by the learnings from these pilots.

EXPAND WORKPLACE CHARGING

Workplace charging provides the opportunity to better integrate renewable energy given the alignment between solar generation and common work schedules, and also serves to relieve customer range anxiety. Additionally, enabling widespread managed workplace charging will allow for significant EV load without driving peak demands. The utilities current pilot programs will include development of workplace charging

stations. However, further efforts to engage businesses and encourage the installation of EVSE at their sites is merited given the importance of developing workplace charging in realizing the benefits of electrifying LDVs.

ELECTRIFY UTILITY VEHICLES

Adopting electric vehicles as part of utility fleets can help to spread awareness among customers as to the availability of EVs. For the near-term this initiative is most feasible for utility LDVs, but MD and HD utility vehicles could also be electrified in the coming years.

ADVOCATE FOR EV-READINESS IN BUILDING CODES

Another way the utilities can help alleviate concerns over insufficient charging infrastructure is by advocating for EV-readiness provisions in building codes. These code changes ensure that L2 charging at residences and businesses is easier to provide in new construction, which will be important as TE in Arizona grows. A local example of EV-ready building code is the City of Flagstaff, which adopted requirements for EV pre-wiring in new construction in June 2019.[155] The City of Tucson will be hearing public comments on proposed EV-readiness amendments to its building code in January 2020.

ENGAGE AUTOMAKERS

Engaging automakers to help reduce the upfront cost premium has proven to be a successful way to spur additional adoption of light-duty EVs. The Nissan LEAF discount program in which APS has participated resulted in meaningful uptake of these vehicles among customers. Partnering with additional automakers to provide similar discounts in exchange for marketing and outreach support to utility customers will help to drive additional EV sales and spread awareness of TE benefits among the customer base.

EXPAND TOU RATE OPTIONS

TOU rate options are an important component of realizing the potential benefits of TE given the implicit economic incentive they provide to charge EVs during off-peak hours. The utilities currently provide TOU rates for different customer types. Expanding these options and actively engaging EV customers to enroll in TOU tariffs will allow TE-related load increases to be accommodated without driving up system peaks and will also allow for integration of renewable resources based on their generation profiles.

ALTERNATE RATE DESIGNS FOR DCFC

Demand charges could serve as an impediment for EVSPs given that their charging stations are not yet utilized at high rates. While this issue will decline with additional EVs on the road, in the near-term it creates challenges for these companies to deploy additional charging infrastructure, especially in lower-traffic areas that are not yet seeing significant numbers of electric vehicles. Exploring alternate rate

[155] City of Flagstaff, "Building Safety," June 18, 2019. Available at: https://www.flagstaff.az.gov/494/Building-Safety.

designs can help to alleviate this constraint, although with other potential rates it will remain important to ensure that utility costs of service continue to be collected.

Commercial Fleets

Electrification of commercial fleets shares some of the challenges of electrifying personal LDVs, but also poses distinct hurdles.

PROVIDE SUFFICIENT EVSE FOR TNC FLEETS

For TNC or taxi fleets in particular, electrification is a challenging proposition given the high mileage driven and the time required to recharge vehicles. Building out additional DCFC infrastructure can help to alleviate this concern and pave the way for additional fleet electrification. The utilities can help with this buildout by either developing DCFC sites themselves, or by preparing the make-ready infrastructure for third-party EVSP sites. As with other public charging, the utilities can help to identify locations with relatively low upgrade costs.

RATE DESIGN

Similar to EVSPs, commercial fleets can face high demand charges given the low utilization of charging infrastructure, reducing or eliminating the operational savings that EVs can offer. The utilities can work with commercial customers to help reduce demand charges through managed charging programs and potentially alternate rate designs.

TRAINING FOR SERVICE TECHNICIANS

An additional impediment to commercial fleet electrification is a lack of qualified service technicians to maintain fleets of EVs. While this is not a barrier that the utilities are likely to address directly, through their relationships such as membership in Electric Vehicles Arizona or the Smart Electric Power Alliance's EV Working Group, utilities can promote the need for additional vocational training opportunities in this area.

8) Phase Two Workplan

In Phase Two the utilities will work with stakeholders, including NGOs and government agencies, to develop a strategic Statewide Transportation Electrification Plan that will focus on the areas of near-term opportunity. Based on the findings of this Phase One report, these areas include personal LDVs, taxi and TNC LDVs, medium-duty parcel vans, truck stop electrification, transport refrigeration units and several nonroad vehicle types.

ADDITIONAL ANALYSIS

Phase Two will include detailed cost-benefit analyses of the electrification of personal LDVs, taxi and TNC LDVs, and medium-duty parcel vans. Less detailed analyses will be conducted for truck stop electrification, transport refrigeration units and several types nonroad equipment, as these TE technologies represent smaller potential opportunities. Conducting these analyses will ensure that programmatic offerings are structured to target the specific vehicles and use cases which provide the benefits expected from TE.

STAKEHOLDER ENGAGEMENT

The Commission Implementation Plan benefitted from the active participation of many stakeholders. The utilities will continue engaging the different parties involved in Arizona's TE efforts while developing the Phase Two plan and will host workshops to discuss proposed programs and initiatives. Areas of discussion could include, for example, gaps in EVSE network coverage that could benefit from utility action or the details of new EV rate designs. These workshops would be held in early to mid-2020 to align with the timing of completing the Phase Two plan.

APS, TEP and UNS Electric will also work with the other Arizona utilities including SRP and the cooperative utilities to ensure that TE initiatives take advantage of synergies and shared efforts where possible. For example, given their neighboring service territories APS and SRP can jointly consider charging station coverage in the Phoenix metro area rather than operating in isolation. APS, TEP and UNS Electric propose to incorporate discussions with the other Arizona utilities early in the Phase Two process to identify areas for collaboration and shared knowledge.

COLLABORATION WITH STATE AND LOCAL AGENCIES

In Phase Two the utilities will also further explore the many opportunities for collaboration with different state and local agencies. Several public entities are either considering or actively implementing TE programs, primarily as a means to improve air quality, and the utilities will explore potential synergies with these groups.

The Arizona Corporation Commission (ACC) will continue to play a critical role in helping to guide the development of the TE sector in Arizona. The utilities will continue to work closely with the Commission

on TE issues, beginning with the implementation of Phase Two of the Statewide Transportation Electrification Plan.

The Arizona Department of Administration (ADOA) is interested in transportation demand management to reduce the number of single-occupancy vehicle trips, which with conventional vehicles contribute significantly to local air pollution. TE is one of the options the agency is exploring through several initiatives. ADOA has installed a dozen Level 2 charging stations at the Capitol complex to provide additional charging options for both commuters and the general public. The agency has also pioneered mobile L2 chargers at the state fair and has purchased a light-duty EV for staff use which will provide useful insights for further programs and initiatives. Through its *Take Charge AZ* program APS will be providing the make-ready infrastructure for one of the workplace charging stations, and opportunities for further collaboration on EVSE deployment and other initiatives exist.

The Arizona Department of Environmental Quality (ADEQ) considers TE one of several important areas for addressing air quality concerns, as described in Chapter 3. While ADEQ does not run specific TE programs they are nonetheless an important partner to engage with, as evidenced by their participation in the ACC proceeding. For example, ADEQ may be a useful partner in informing the air quality considerations in future cost-benefit analyses of TE options.

The three agencies in Arizona responsible for meeting the National Ambient Air Quality Standards (NAAQS) at the county level will also be key partners:

- The Maricopa County Air Quality Department (MCAQD) provides information to the public on grants, incentives, and permits related to EVs. Most of MCAQD's existing initiatives to reduce transportation emissions focus on behavior changes for drivers with ICE vehicles, such as the Diesel Emissions Reduction Program which provides grants to reduce emissions from diesel-powered vehicles. Partnership with MCAQD on these or other EV-related programs presents an opportunity to expand TE in Maricopa County.
- The Pima County Department of Environmental Quality (PDEQ) has identified transportation as an essential pillar of improving local air pollution and environmental quality. A 2018 PAG report (using data from PDEQ) highlights truck stop electrification and electrified ground support equipment – two of the non-LDV, near-term initiatives discussed in this report – as areas for potential nitrogen oxide (NO_X) reduction,[156] presenting an opportunity for collaboration with TEP.
- The Pinal County Air Quality Control District (PCAQCD) is the third county agency in Arizona responsible for NAAQS attainment at the local level. As TE expands – including the deployment of additional EVSE along interstates such as the I-10 corridor between Phoenix and Tucson – PCAQCD may be a valuable partner to work with given its mandate to maintain air quality standards within Pinal County.

The Arizona Department of Transportation (ADOT) adopted the most recent Long-Range Transportation Plan in February 2018, which covers a 25-year planning horizon from 2016-2040 and aims to provide

[156] Pima Association of Governments, "2018 Ozone Status Report," December 2018. Available at: http://www.pagregion.com/documents/air/2018OzoneStatusReport.pdf.

information and direction to metropolitan planning organizations and local governments. While the current plan does not focus on TE, this planning process presents an opportunity for the utilities to engage with ADOT and to help inform the investments needed to support an expanded population of EVs.

The Maricopa Association of Governments (MAG) works with APS and SRP on air quality issues, and representatives of both utilities are members on the Air Quality Technical Advisory Committee. MAG has identified transitioning to EVs as one of the key opportunities for continuing to improve air quality in Maricopa County, and the group is enthusiastic about continued collaboration with the utilities. One specific area for potential collaboration is through MAG's ongoing transportation planning process, scheduled for a 2022 review by the member cities. MAG members have expressed interest in deploying additional charging stations and welcome learnings that the utilities can provide in this area.

The Pima Association of Governments (PAG) organizes strategic transportation plans for the Tucson area. The 2020-2024 Transportation Improvement Program focuses primarily on local air pollution and highlights alternative modes of transportation as the key methods for reducing air pollution, indicating one potential area for collaboration on TE. The longer-term Regional Transportation Plans (updates are released every four years) present an additional opportunity for partnership with PAG on developing the infrastructure necessary to support a robust TE system in Pima County.

The Arizona Commerce Authority (ACA) is primarily involved with TE through its role in overseeing the Institute of Automated Mobility (IAM) established in 2018. While the focus of the IAM has thus far predominantly been on vehicle safety, there may be future opportunities to leverage the collaborative relationships developed through the IAM, including AV companies that are basing their platforms on EVs. For example, APS has collaborated with the ACA in the past on a funding proposal to the U.S. Department of Transportation for DCFC to support AVs.

Arizona Governor Ducey has made addressing air quality concerns a priority for his administration, and he recognizes that vehicles contribute heavily to this issue. While the 2020 policy planning process is ongoing at the Governor's Office, there may be opportunity to collaborate on TE initiatives in the future.

PHASE TWO TIMELINE

The utilities propose to initiate the Phase Two process in early 2020, with a targeted completion date by June 30, 2020. This timeline will allow for gathering additional insights from pilot programs, detailed analyses of different vehicle types and potential program offerings, and stakeholder outreach and engagement including collaboration with public agencies.

Appendix A: Public Entities Interviewed

In developing this Phase One report interviews with state and local agencies involved in transportation electrification and air quality planning were conducted to identify areas of opportunity and potential collaboration. Interviewed agencies are listed below. The utilities recognize that this is not an exhaustive list of agencies involved in these discussions, and plan to continue engaging with not only these agencies but also other public entities as the TE plan is further developed in Phase Two.

- Arizona Commerce Authority (ACA)
- Arizona Department of Administration (ADOA)
- Arizona Department of Environmental Quality (ADEQ)
- Arizona Governor's Office
- Maricopa Association of Governments (MAG)
- Residential Utility Consumer Office (RUCO)

Appendix B: Abbreviations and Acronyms

ACA	Arizona Commerce Authority
ACC	Arizona Corporation Commission
ADEQ	Arizona Department of Environmental Quality
ADOA	Arizona Department of Administration
ADOT	Arizona Department of Transportation
AFV	Alternative Fuel Vehicle
AV	Automated Vehicles (sometimes referred to as autonomous vehicles)
BEV	Battery Electric Vehicle
CAA	Clean Air Act
CARB	California Air Resource Board
CNG	Compressed Natural Gas
CPUC	California Public Utilities Commission
DCFC	DC Fast Charging
DOT	U.S. Department of Transportation
DR	Demand Response
E3	Energy and Environmental Economics, Inc.
e-GSE	electric-powered Ground Support Equipment
eTRU	electric Transport Refrigeration Unit
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
EVSP	Electric Vehicle Service Provider
FCV	Fuel Cell Vehicle
FAA	Federal Aviation Administration
GHG	Greenhouse Gas
I-10	Interstate Highway 10
I-40	Interstate Highway 40
ICE	Internal Combustion Engine
IOU	Investor Owned Utility
HD	Heavy-Duty
HPUC	Hawai'i Public Utilities Commission
HDV	Heavy-Duty Vehicle
HOV	High Occupancy Vehicle
L2	Level 2
L3	Level 3 (also known as DCFC or DC Fast Charging)
LDV	Light-Duty Vehicle
MAG	Maricopa Association of Governments
MCAQD	Maricopa County Air Quality Department
MD	Medium-Duty

MDV	Medium-Duty Vehicle
MOU	Memorandum of Understanding
MSRP	Manufacturer's Suggested Retail Price
MUD	Multi-Unit Dwelling
NAAQS	National Ambient Air Quality Standards
NGO	Non-governmental Organization
NO_X	Nitrogen Oxide
NREL	National Renewable Energy Laboratory
PAG	Pima Association of Governments
PCAQCD	Pinal County Air Quality Control District
PDEQ	Pima County Department of Environmental Quality
PEV	Plug-In Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PM_{10}	Particulate Matter with Diameters ≤ 10 Micrometers
PPB	Parts Per Billion
R&D	Research and Development
RUCO	Residential Utility Consumer Office
SIP	State Implementation Plan
SWEEP	Southwest Energy Efficiency Project
TCO	Total Cost of Ownership
TE	Transportation Electrification
TNC	Transportation Network Company
TOU	Time-of-Use
TRL	Technology Readiness Level
TRU	Transport Refrigeration Unit
TSE	Truck Stop Electrification
V2G	Vehicle to Grid
VALE	Voluntary Airport Low Emissions Program
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
ZEV	Zero Emissions Vehicle